

A Moonraker's Guide to
RIGGING

By A. Richard Mansir

a MOONRAKER PUBLICATION

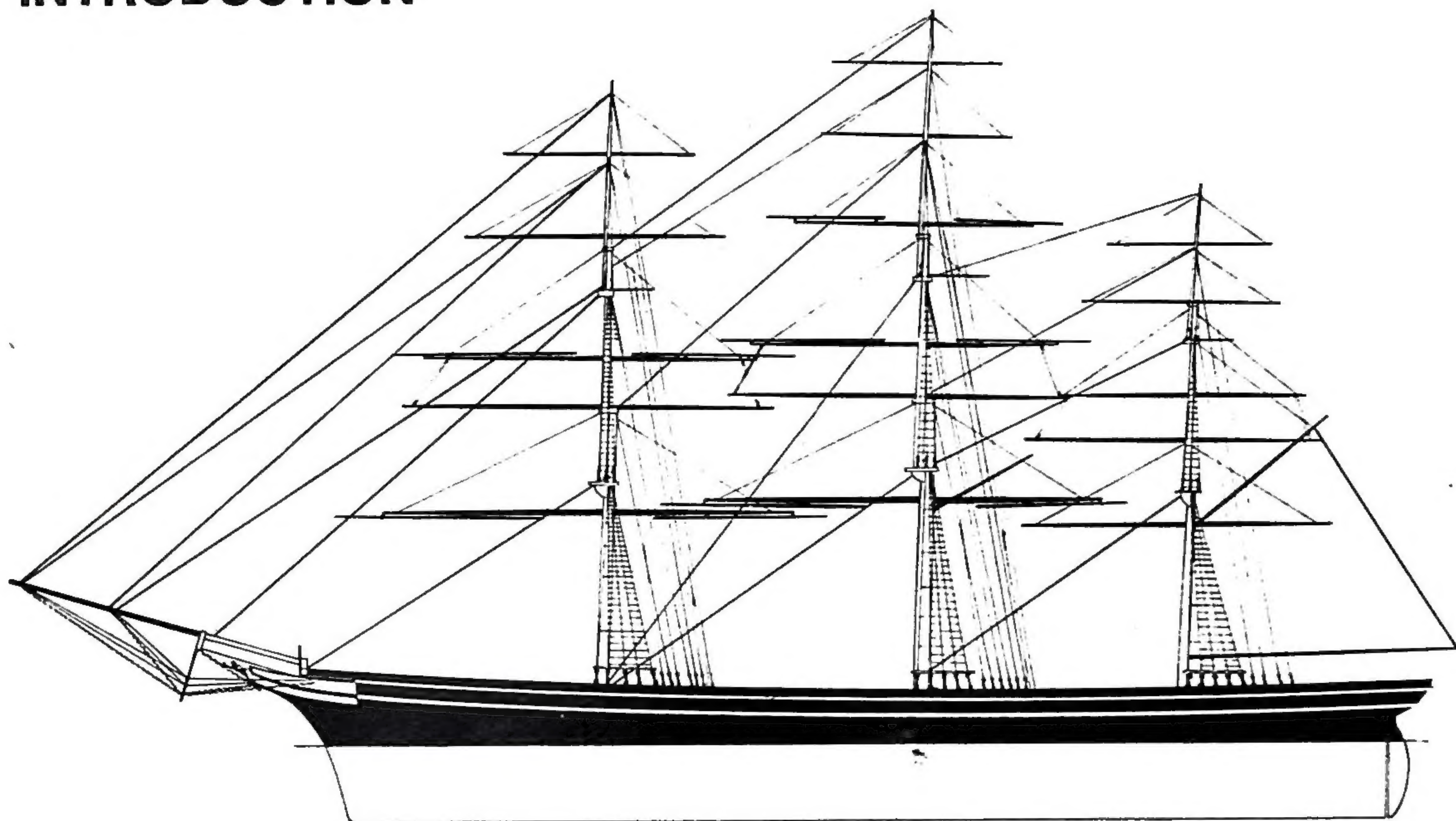




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INTRODUCTION



FULL RIGGED SHIP
Cutty Sark 1869
Length—212' — 963 tons

"A sea went by downwind snarling at the vessel. The wind felt cold. He buttoned his shirt. They hit a patch of fog. Someone forward began to crank the horn. He swung into the weather rigging and made his way aloft till he reached the doublings of the topgallant mast. There he sat, his ass on the swifter, his right hand filled with a backstay . . . He looked up ahead through the sharp-etched gear of the foremast. . . ."

Voyage, A Novel of 1896, Sterling Hayden.

Hayden's description of a sailor aloft in the rigging of a giant square rigger repeats a scene lived a million times in the history of seafaring, and catches a trace of the intimacy seamen had with their special world of rope, cable and tar.

To ring true, a ship model must reflect a similar intimacy, while a modeller can find special satisfaction in understanding this most important aspect of the seaman's trade.

This book is designed to expand the modeller's understanding of some of the more important details of sailing ship rigging. We have briefly sketched rigging from the earliest times to 1900 with special attention to the periods after 1600. There are sections on the material and method of rope making; the working of rope; ship hardware; the

types of sails and rigs; standing and running rigging; masts, yards, and spars and tips for modelling.

Certain technical terms appear which have been defined in the author's earlier works ("How to Build Ship Models, A Beginner's Guide" and "A Modeller's Guide to Hull Construction"). For this reason they have not been redefined here. The reader is referred to the earlier works for clarification of such points.

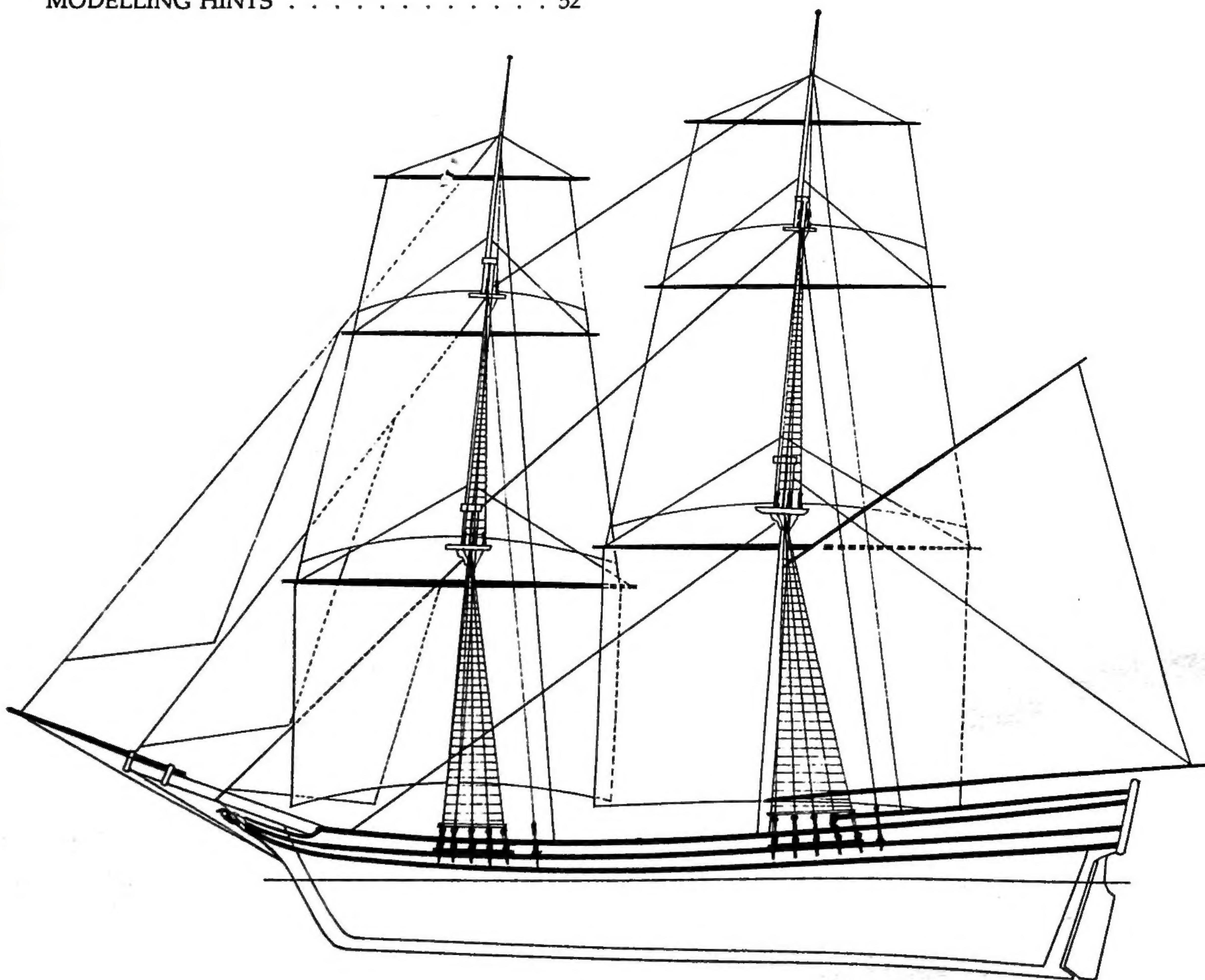
Much of the book reflects English rigging practice, which in broad outline is very close to the practice of all Europe and America. There are, however, differences in detail among the various countries which we have not shown. For other than English ships, therefore, the modeller is advised to undertake some additional research.

In fact, part of our purpose is to invite the modeller to take advantage of the wealth of technical data available to him in the museums and libraries around the world. To this end we have included some examples of the kind of information he can expect to find.

Maritime lore is as deep and broad as the oceans on which it is built. We hope this book will help the modeller off soundings on his voyage of discovery.

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BRIG
Swift 1778
 Length—75'-6" — 144 tons

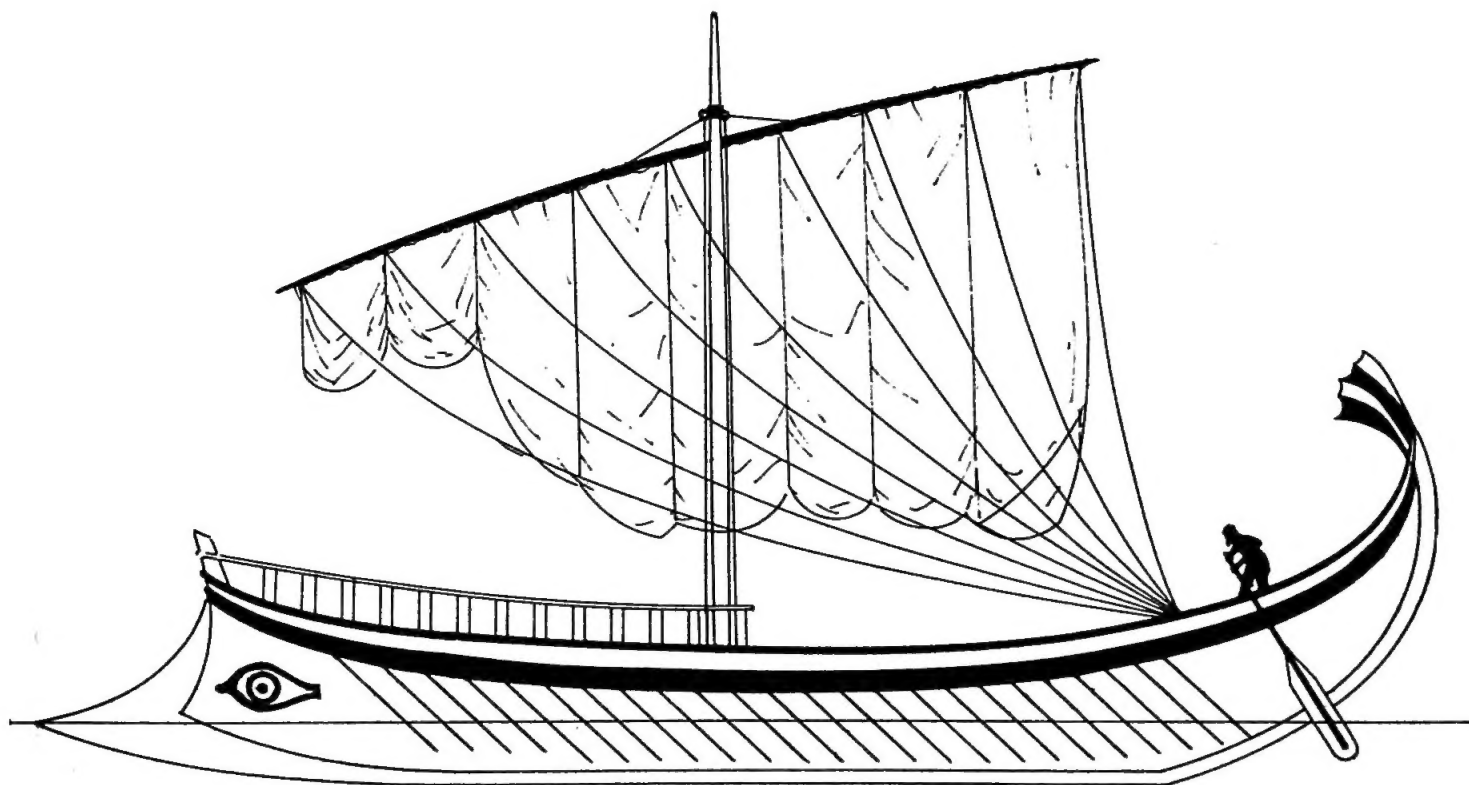
HISTORICAL SURVEY

Men have been sailing a long time though no one knows how long. An Egyptian clay urn with a sail boat painted on it from about 4000 B.C. is the oldest archaeological evidence we have of sailing, but chances are sails were in use well before then.

The history of sail becomes clearer after 3400 B.C. when the Egyptians began to record their activities in hieroglyphics. The hieroglyph for "South" is a ship with a sail, because ships only sailed south (up the River Nile) in the morning northerly breeze. The hieroglyph for "North" is a ship without a sail. Sails were struck when traveling down stream. Sailing for the Egyptians was strictly a downwind proposition. The ships reflect their conviction. They were fitted with bi-pod masts stepped well forward so that they could be lowered aft into the hull when not in use. The masts were hoisted by an elaborate array of shrouds

(or halyards) arranged to counter wind force only from the rear. The single square sail could be braced around only a little bit.

By 1500 B.C., the Egyptians had refined their ship building skills. Queen Hatshepsut, co-regent and sister of the pharaoh Thotmes, for example, organized a five ship fleet for a trading voyage to Punt, thought to be present day Somalia or Rhodesia. This was a long voyage for the period and testifies to the seafaring sophistication of the people who lived then. Hatshepsut's ships had masts stepped amidships. A single spar replaced the earlier bi-pod. The square sail is spread between two yards, the lower of which was rigged with an elaborate system of lifts or halyards. Both yards were equipped with braces while bridles from the upper yard to the outermost lifts of the lower one seem designed to keep the two yards in trim. The



GREEK PENTECOSTER
Odysseus' Ship 1200 BC
Length—approximately 50'

HISTORY

mast is supported by a stout backstay and two lighter forestays which apparently were freed as the ship was weared around to a new tack.

Such a rig made it possible to brace the sail nearly fore and aft, and so catch wind from abeam. But the strong support aft with little support forward suggests that downwind sailing was the Egyptian's main concern.

This information about Hatshepsut's ships comes from relief carvings in the temple at Deir el-Bahari in Thebes.

CRETE, PHOENICIA, GREECE

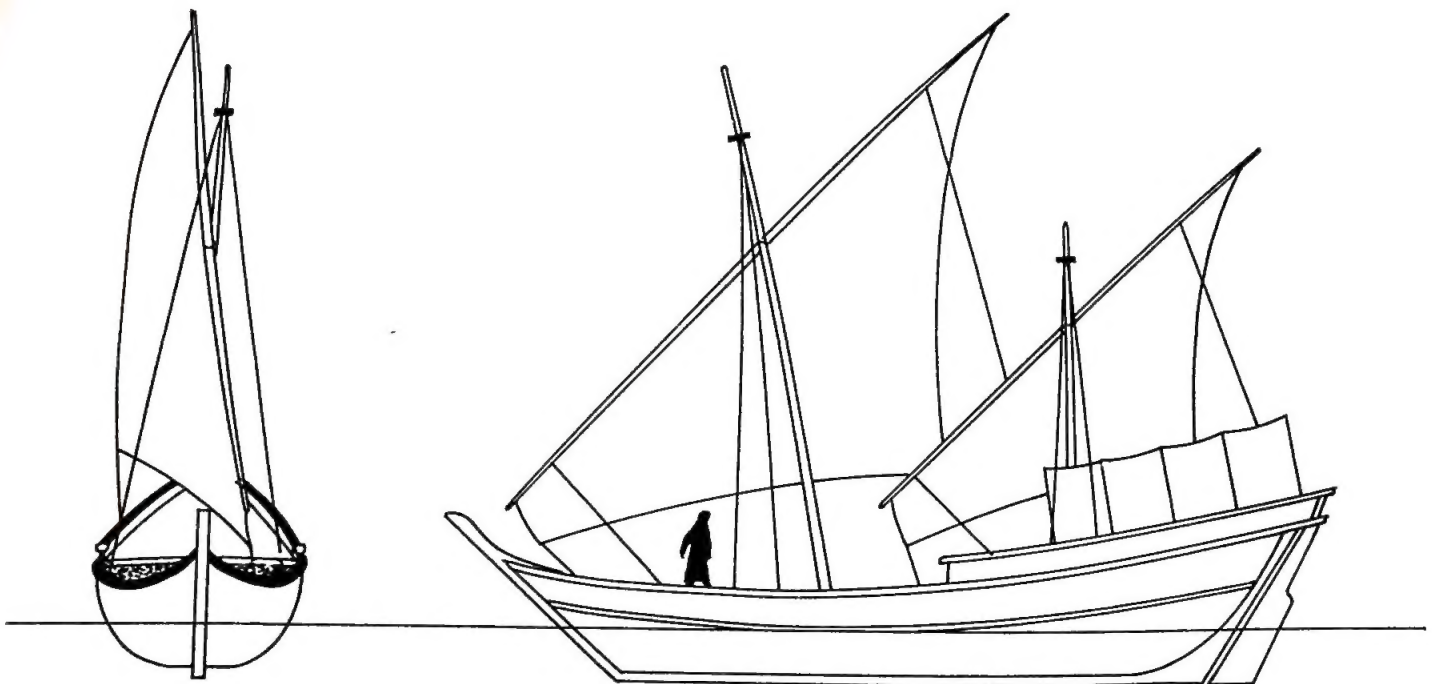
The islands of the Aegean Sea around 1500 B.C. supported a rapidly growing seafaring civilization. Crete, Syria, Phoenicia and the ancient Greeks depended on ships as the foundation of their livelihoods as traders, pirates and fishermen. This was the day of the great Greek sea-adventurers, such as Jason of the Golden Fleece, who explored northward into the Black Sea.

In 1300 B.C., Crete reigned supreme in the south-east Mediterranean under the Greek sea-lord, Minos.

We know that these people had to be great sailors—but what were their ships like? Less is known about them than the Egyptians but we have enough data to form an idea.

Among the hints are those in Homer's poems about the Trojan war. This war was supposed to have ended in 1183 B.C., two or three hundred years after the heyday of Mycenae, but since things developed slowly in those days, the ships of Troy probably were not very different from Jason's Argo, nor different from the ships of Homer's day 300 years later.

Homer tells us that Agamemnon led the Achaens (Greeks) against the city of Troy with a fleet of more than a thousand ships. Various he refers to them as "the curved ships"; "the black ships"; "hollow ships"; "decked ships"; "dark prowed ships"; "well timbered ships"; and "beaked" or

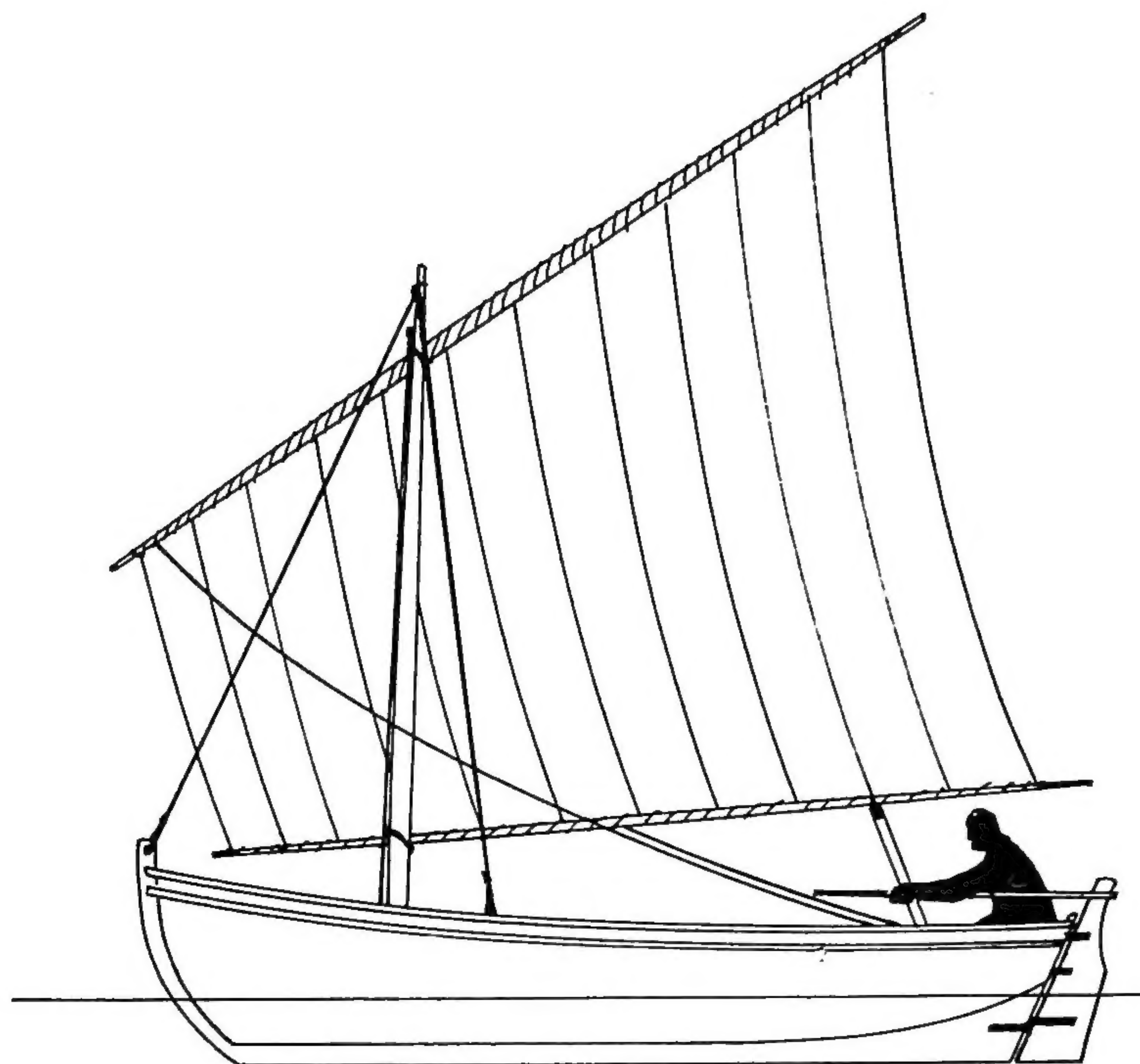


ARAB DHOW 800 AD

Lateen Rig

The earliest fore and aft rig made it possible to sail by the wind. Yards were dipped down and around the mast when coming about.

HISTORY



DIPPING LUG RIG

Later adaptation of the lateen rig in which the spar is dipped down and around the mast when coming about.

"black beaked ships." Once he refers to an oarsmen's bench as "seven feet long." He says they . . . "raised the mast of pine tree and set it in the hold of the cross plank, and made it fast with forestays and hauled up the white sails with twisted ropes of oxhide."

At one point, the demi-goddess, Calypso, helps Odysseus build a sailing raft. This is how the project proceeds:

"Next she (Calypso) gave him a polished adze, and she led the way to the border of the isle where tall trees grew, alder and poplar and pine that reacheth unto heaven, seasoned long and sere, that might lightly float for him . . . And he set to cutting timber . . . twenty trees in all . . . (Calypso) brought him augers, so he bored each piece and jointed them together, and then made all fast with trenails and dowels . . . and therein he set a mast and a yard-arm fitted thereto and moreover he made a rudder to guide the craft . . . (Calypso) brought him a web of cloth to make his sails; . . . And he made fast therein braces and halyards and sheets; . . .

Homer explains also that ". . . the vessel in full course ran ashore, half her keel's length high." He also describes Odysseus' fleet as ". . . ships of

vermilion prow." In another place, he tells us that one hero's ship rowed 50 oars.

What can be made of these hints? First we can infer a decked or partially decked, oar driven craft, between 35 and 80 feet long. They were planked wooden ships with keels trenailed together and fairly shallow of draft. The "beaked prow" refers to a ram-rod as seen on later representations of Phoenician and Greek warships. They were waterproofed with pitch (black ships), and had a decorative painted bow. They carried a single mast with a square sail and the rigging was oxhide rope.

These hints as well as evidence from other sources leads us to conclude that the ships of the Trojan war and Jason's Argo were, in fact, direct copies of the Phoenician war galleys called penteconters.

Sometime after 1000 B.C. "oxhide" rope gave way to hemp or linen rope for rigging. In this period also the Phoenicians on their big trading vessels introduced a second mast or perhaps more accurately a very high steeved bowsprit on which they rigged a second square sail. The masts for the first time are held aloft with shrouds and stays set up with deadeyes.

HISTORY

These innovations seem to be about all that occurred in the development of rigging until the Romans started using triangular topsails around the time of Christ. Otherwise the single square sail remained a constant that saw little change until the Middle Ages.

THE LATEEN RIG

The next most significant milestone in the evolution of sail was the development of the lateen rig. The lateen rig is characterized by a triangular sail set on a yard trimmed diagonally across the mast in a fore and aft direction. For the first time we have a rig with the potential for working a ship to windward. Exactly when the lateen rig appeared on the scene is unknown except that it was certainly around by 100 A.D. A tombstone found at Piraeus, near Rome, has a lateen rigged ship carved on it.

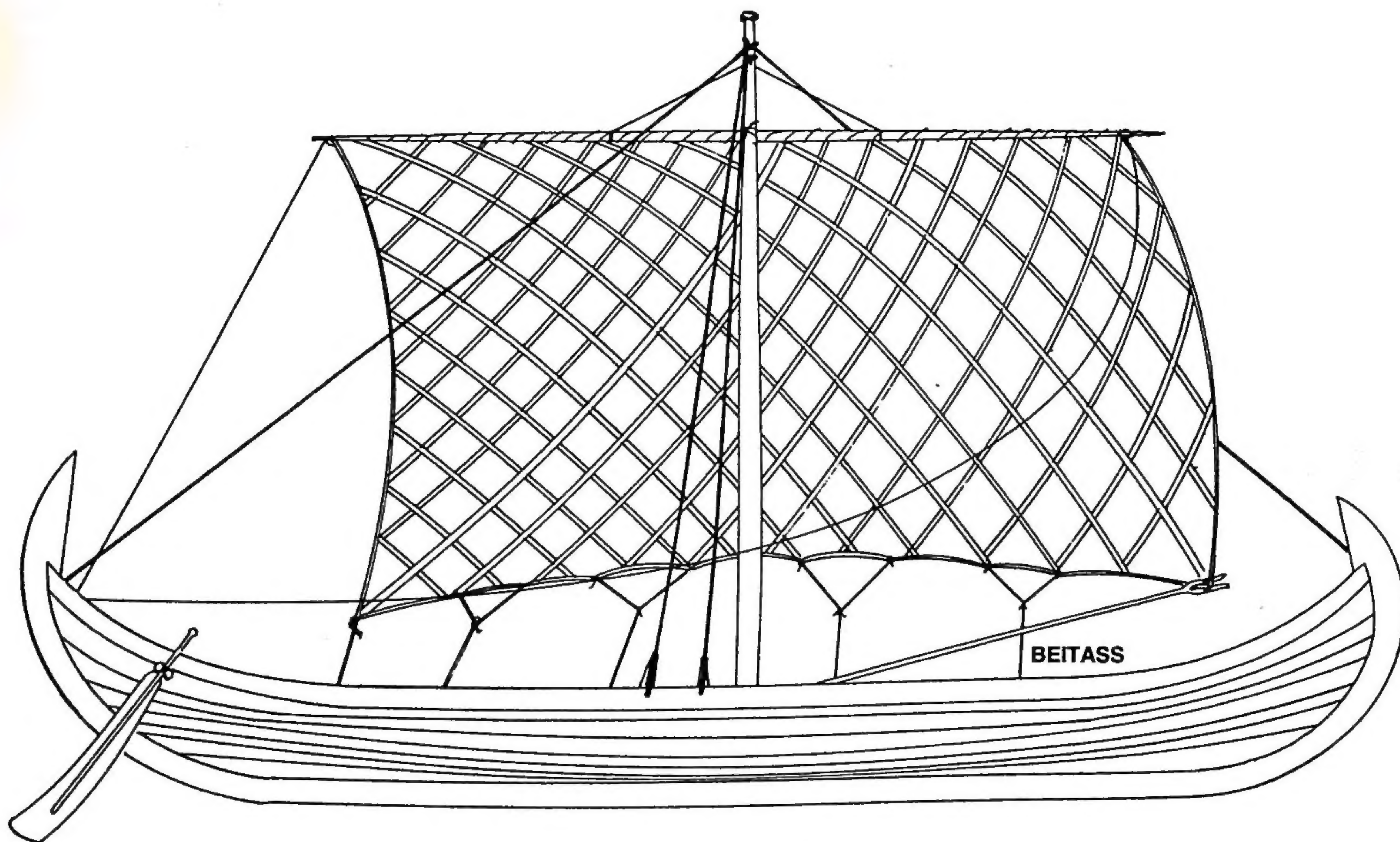
The value of the rig, however, apparently was overlooked by the majority of sailors for a long time. It seems not to have become popular until around 700 A.D. when the Arab empire began to

spread. At this time, the Arabs invented the two-masted lateen rigged dhow and the felucca which are seen in Egypt and the Eastern Mediterranean today.

The reason the lateen rig did not catch on perhaps, is because it is a bit clumsy. To change tack the procedure is to let go the tack (or bowline as it is called with lateen sails), and the sheet, and haul the yard up vertically, fore end down, and dip it around the mast to the new lee side. In any kind of sea, this would have been a trick.

THE NORSEMEN

The Norsemen made the next big contribution to sailing. They invented the *beitass*, a light spar, like a modern spinnaker pole, which could hold the forward, lower corner of the sail forward when the yard was braced back parallel with keel. This invention made it possible to set a square sail to take the wind abeam and so come closer to the solution of sailing up-wind. Here we have the northerner's answer to the southerner's fore and aft lateen sail.



VIKING SHIP 900 AD
Square sail rigged with *beitass* made it possible to trim the sail fore and aft in order to sail closer to the wind.

HISTORY

The next step in the evolution found the beitass fitted as a permanent spar in front of the ship and renamed the bowsprit.

New lines appeared with the new spar. The beitass was hooked directly into the clew of the sail. With the bowsprit, a rigging line called the tack was tied to the corner of the sail and bowlines were rigged to the forward leech. These lines then led forward to the bowsprit through blocks and back to the foredeck where they were belayed.

The bowsprit apparently came into use between 1100 and 1200 A.D. William the Conqueror's ships of 1066 A.D. lacked bowsprits while the Swedish ship found at Kalmar dated 1250 A.D., had one.

THE MIDDLE AGES

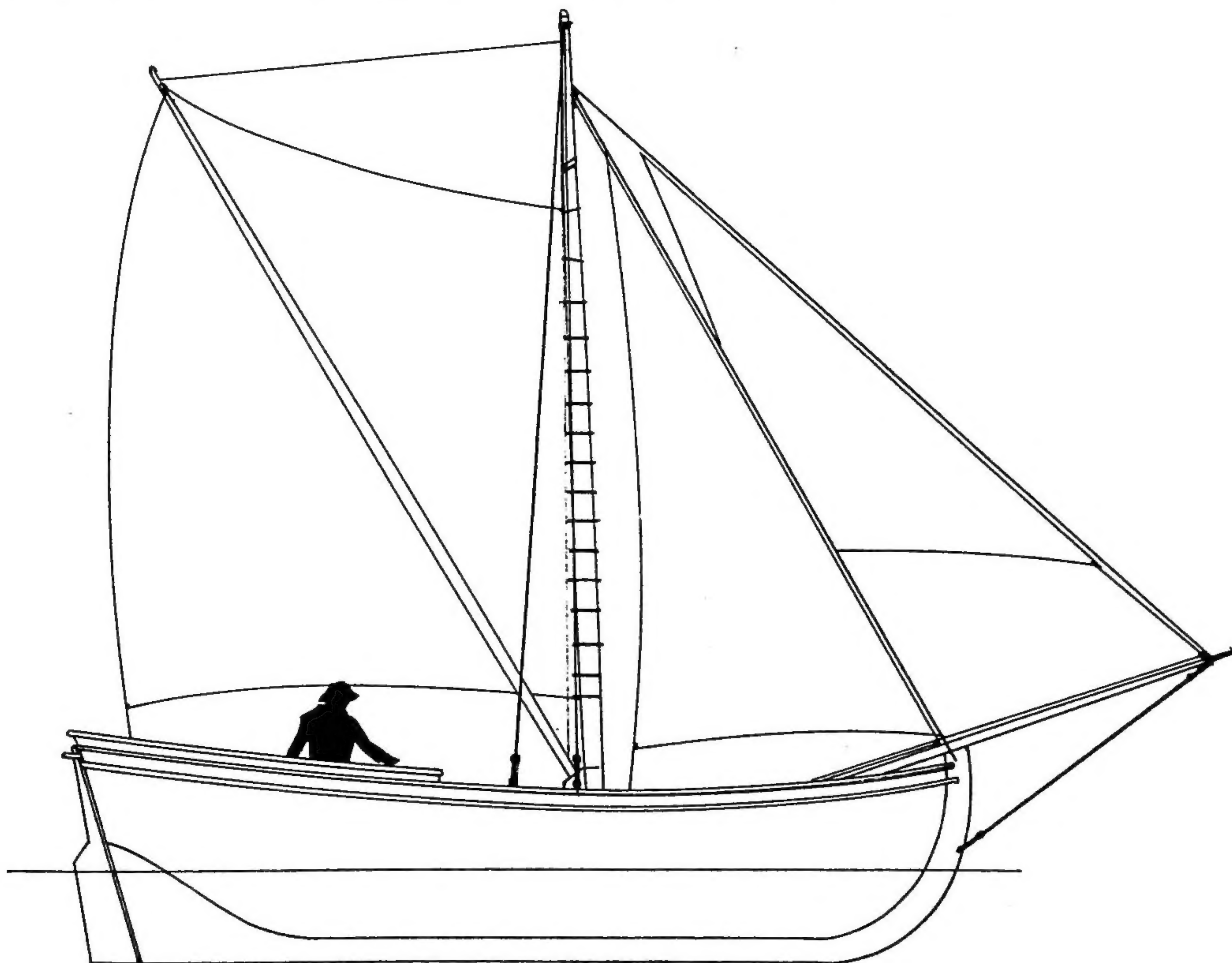
During the crusades between 1100 and 1400 A.D., ships in the Mediterranean grew in size and began to ship two or three masts. The standing rigging for the masts had become by this time what it was to remain until our own day. Stays held the

masts forward along the centerline of the vessel; shrouds led aft and out to the ship sides.

The rigging itself, however, was comparatively light, while the masts were massive towers of wood. Largely the masts were expected to support themselves without any rigging at all.

Masts also began to be fitted with fighting tops, and flagstaffs, raised above the tops announced the coming of the first topmasts.

Advances in rigging came rapidly after 1400 largely as a result of the development of the naval cannon. As the idea of mounting larger and larger guns on a ship took hold it became necessary to build heavier hulls and develop more powerful rigs to drive them. In the early 1400's we see the first diminutive topsails, which continued to grow in size through the century. The topmasts spawned topgallant masts and a third sail was stacked over the first two. During this century we see the development of the three-masted rig that remained the standard from that time on.



SPRIT RIG

Introduced by the Dutch in the 14th century, the sprit rig provided another solution to the problem of sailing upwind.

HISTORY

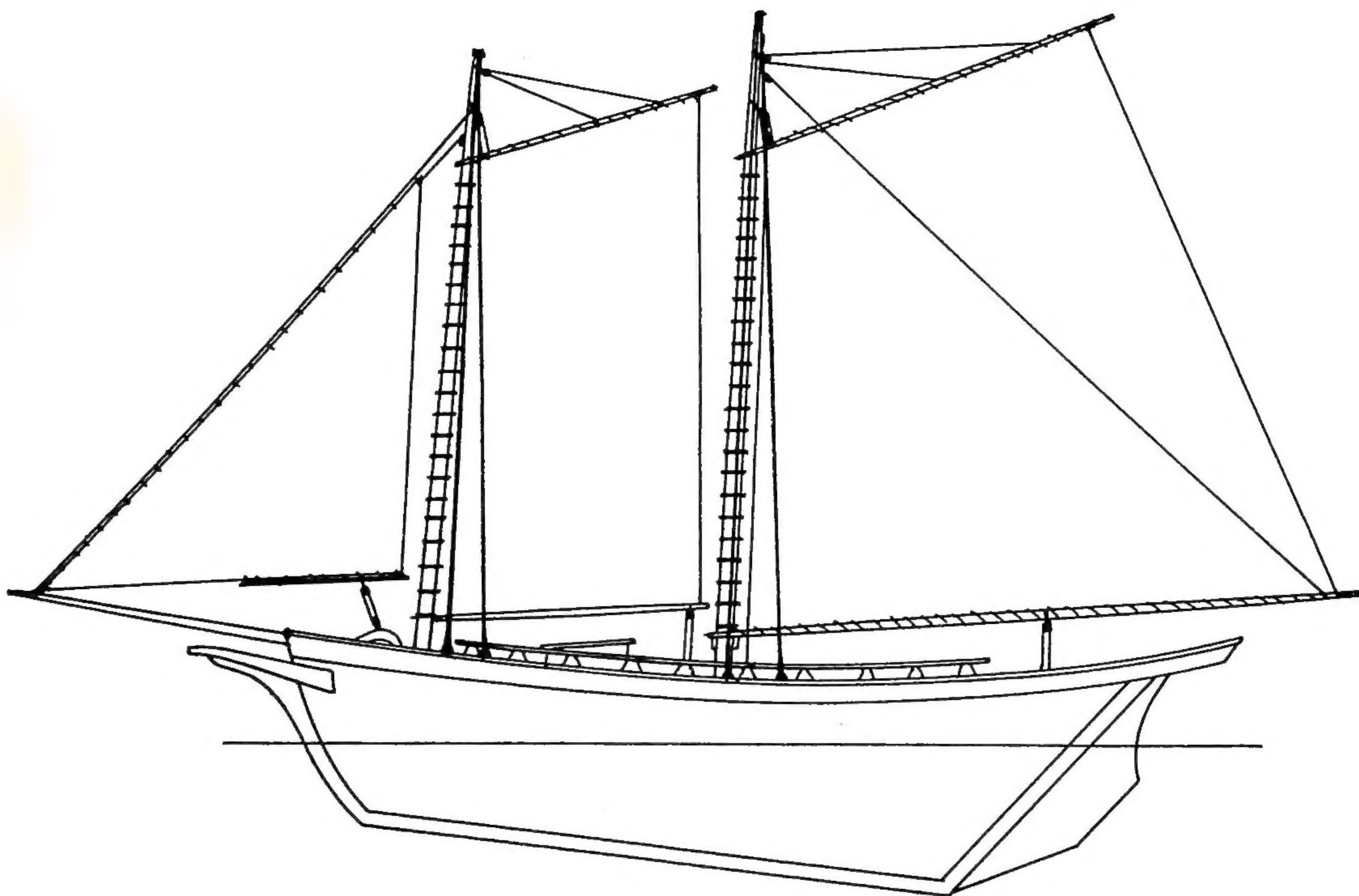
THE AGE OF EXPLORATION

The 15th century ushered in the great age of exploration. In 1488, Bartholomew Diaz de Novaes discovered the Cape of Good Hope. In 1492 Columbus found the Americas and Vasco de Gama sailed around Africa to India in 1498. Columbus's ships, perhaps the most famous in history, deserve comment.

The Santa Maria, the flagship and largest of Columbus's fleet, was a small, full-rigged ship with three masts. While topsails and topgallant sails were in use on large vessels of this period, the Santa Maria flew only a small main topsail. Other-

wise she carried a square spritsail, square fore and main courses and a lateen mizzen. Three-masted Pinta carried no topsail or spritsail, while Nina, the smallest of the fleet, sailed under lateen sails on all three masts. The Nina was typical of the *cara-vella latina*, which the Portuguese and Spaniards preferred for their long distance voyages of discovery.

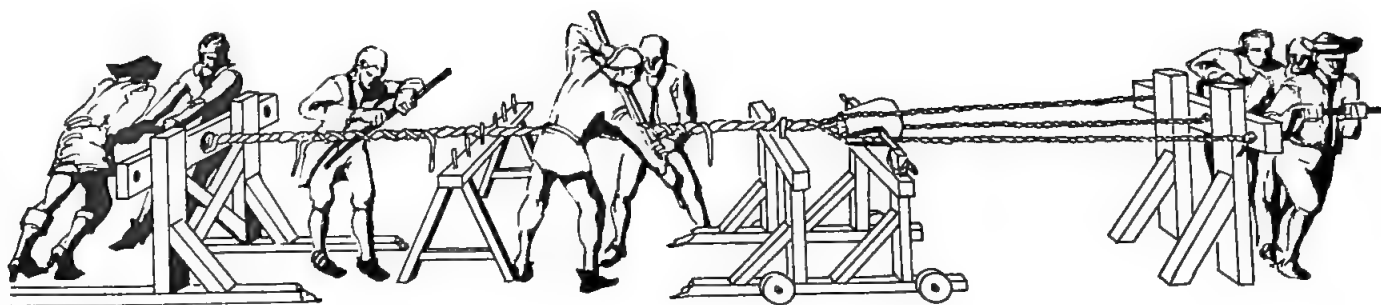
Through the 16th century, ships continued to grow larger but their rigging was only an elaboration of the essential theme laid down in the previous century. This theme will be dealt with in detail later in this book.



PINKY SCHOONER 1775

The gaff headed schooner rigs of the pinkies typify the final step in the evolution of fore and aft rigs before the introduction of modern yacht "Bermuda" rigs.

ROPE



An 18th century ropewalk after an illustration in J. H. Roding's "Allgemeines Wörterbuch der Marine," 1798.

Rope was the sailor's constant companion. Awake or asleep he depended on rope for survival, for comfort and for amusement. Rope not only controlled masts, sails and spars, but made up the hammock nettings of the sailor's bed and served as the raw material for artistic expression during long passages. Such intimacy often made up the sum of a sailor's intellectual life. He knew by looking how strong a rope was, what it was made of, how old it was, how it would behave when wet, dry, hot or cold, where it was weak, how to fix it, splice it, tie it, bend it, whip it, worm it, weave it, and above all how to make it handsome.

The modeller who understands and appreciates these details, even though many of them are too small to duplicate in scale, can come to the job of rigging his miniature ship in the spirit of the real seaman, rather than the "oh, well, it will do!" attitude of the land lubber. At sea, the sailor learned quickly that a slipshod approach to ropework was a certain invitation to disaster.

Rope is among the earliest of man's inventions. He probably learned to make it about the same time that he learned to weave about 6000 years ago during the neolithic or last stone age. The neolithic lake dwellers of Switzerland made linen cloth from flax which might well have been the first rope-making material. Certainly flax is among the oldest vegetable fibers man has put to use.

Hemp, however, eventually became the primary material for rope making. Precisely when this occurred is difficult to say because the different cultures of the ancient world developed at different rates with different access to raw materials.

Hemp was originally an Asian plant indigenous to the territory of ancient Sumeria which flourished about 3000 to 1000 B.C. The Sumerians, therefore,

may be responsible for the introduction of the material for rope making. In any event, hemp rope had become the standard from the days of Alexander (300 B.C.) forward.

Hemp, *cannabis sativa* was transplanted to Europe and later to North America where today it is grown as a cash crop specifically to make rope.

The Portuguese and Spanish during their explorations of the 15th and 16th centuries introduced Europe to a new variety of "hemp" which grew only in the Philippines. The material, taken from a banana-like plant called *abaca*, proved tougher, smoother and more weather resistant than true hemp and rapidly took over as the preferred material for ship rigging. The material became known as Manila hemp.

As Europeans investigated other parts of the world they discovered more fibers adaptable to rope making, though none of them matched Manila for seagoing purposes. Sisal hemp, about 75% the strength of Manila, and derived from the *agave* plant found in South America, Mexico, and Africa, turned out to be the next best choice.

Jute from India, derived from a variety of linden plant, was inexpensive but far weaker than Manila, true hemp or sisal. Jute was used for chafing gear, padding of one kind or another, and later as a core for steel wire ropes.

Coir rope is made from the outer husk of the coconut. It has only a quarter of the strength of Manila, but it floats and stands up well in water. Coir was valuable on shipboard when used as a sea anchor. The rope could be paid out astern in a blow without sinking and so helped to keep the ship's bow into the wind.

New Zealand hemp or flax was a late comer in the quest for natural rope fibers, and turned out to be on a par with Manila for strength and durability.

ROPE MAKING

The useful fibers of these rope raw materials, lay for the most part in the inner bark of the various plants described above. Separating them involved a process of allowing the rest of the plant to rot away. This was accomplished either by soaking the stalks in water (water retting) or hanging them out in the weather for a period (dew retting). When rotten enough, the stalks were beaten with a club and the fibers picked out.

Next the fibers were combed into ribbons which in turn were twisted into yarns. Depending on whether one was making "Z" laid rope or cable laid rope the yarns were twisted either right-handed (clockwise) or left handed (counterclockwise). A half dozen or more twisted yarns then were twisted together in the opposite direction

to make up strands. Three (sometimes four) strands were finally twisted together in the same direction as the yarns to make up the finished rope.

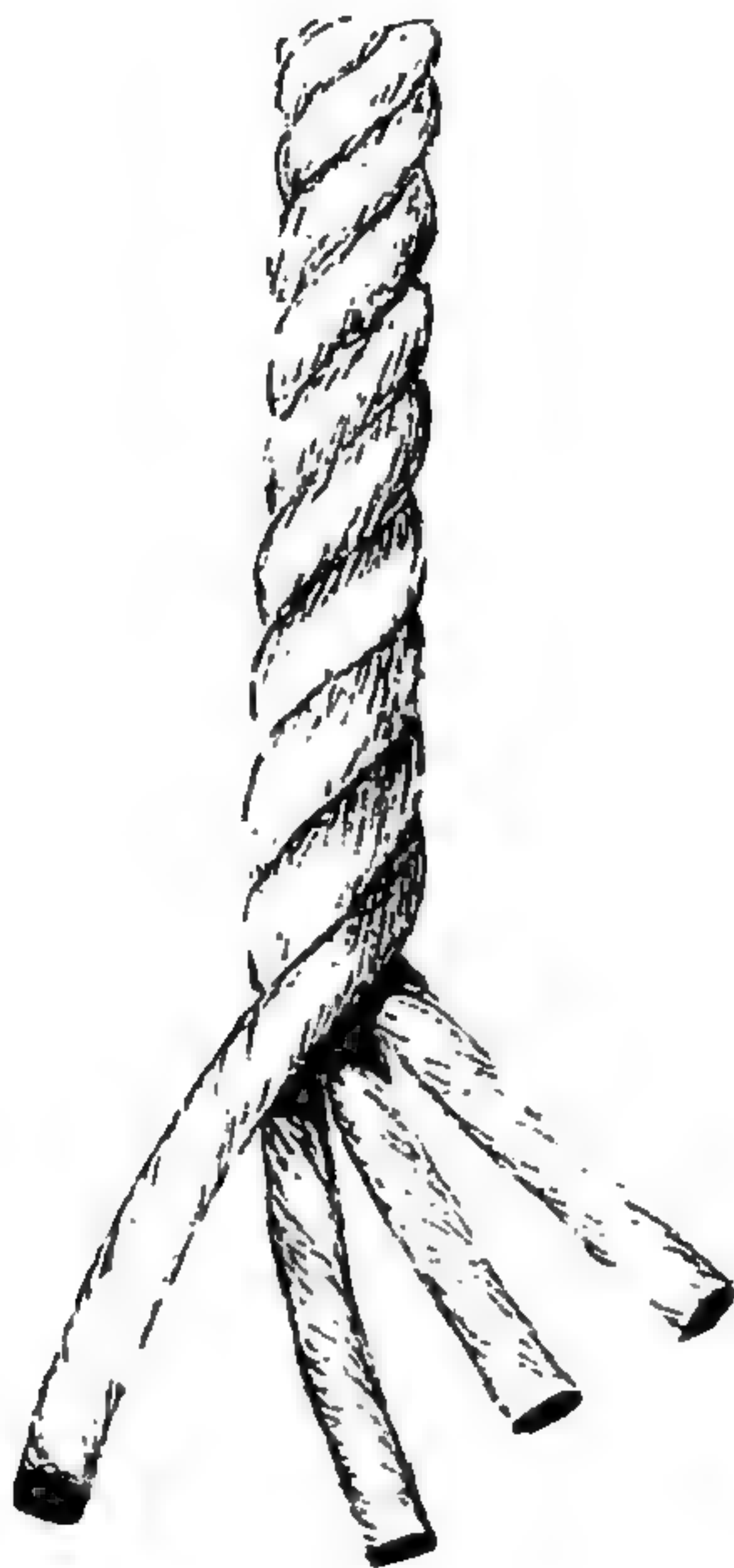
Until the arrival of steel wire rigging in the middle of the 19th century, seamen concerned themselves with three kinds of line and cable—hawser laid (right handed) rope shroud laid (four stranded, right handed) rope, and cable laid (left handed) rope.

The left handed cable laid rope was usually a heavy line made up of three hawser laid ropes, hence "9 stranded."

The strength of any of these ropes, of course, depended on the number of yarns per strand (hence the size) and the fiber material. But a rule-



Three-stranded **HAWSER LAID** rope ("Z" laid) twists from right to left, counterclockwise.



Four stranded **SHROUD LAID** rope also twists from right to left, counterclockwise.



Nine stranded **CABLE LAID** rope, twists three hawser laid ropes together in a clockwise direction.

of-thumb for rope strength (presumably fairly new Manila hemp) came into use in the 18th century. The rule was to divide the square of the circumference of the rope by 3 to get the number of tons required to break it. As a margin of safety, a rope was never used to handle a load greater than 1/6th of its breaking load.

Ropes were protected against fraying, chafing, rotting and unravelling in a variety of ways. Many lines, particularly in the standing rigging were soaked with tar to protect them from the corrosive effects of the salty sea.

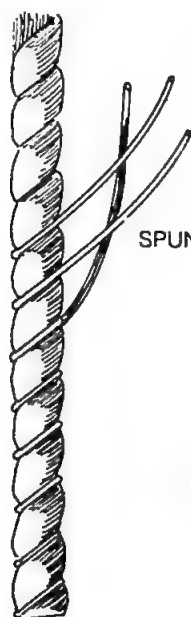
Large portions of the standing rigging were also wormed, parcelled, and served. To worm a rope

was to lay thin line in the cunting (the spiral cracks) between the strands. Parcelling was to wrap old strips of canvas over the wormed line after which the whole was served, or wrapped around and around with marline or spun yarn.

Spun yarn was simply two or three rope yarns (frequently derived by picking apart old rope) loosely twisted into string. Marline was essentially the same thing but twisted tighter and factory made.

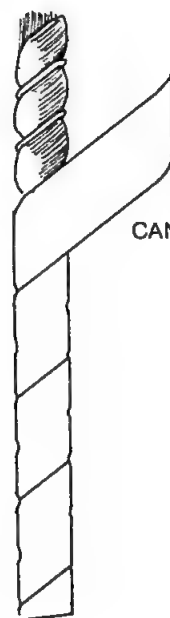
The ends of rope were whipped, pointed or knotted depending on the need.

The size of rope used for each of the many rigging lines varied extensively from ship to ship and era to era. More will be said of this later.



SPUN YARN

"Worm and parcel with the lay; serve it tight the other way"



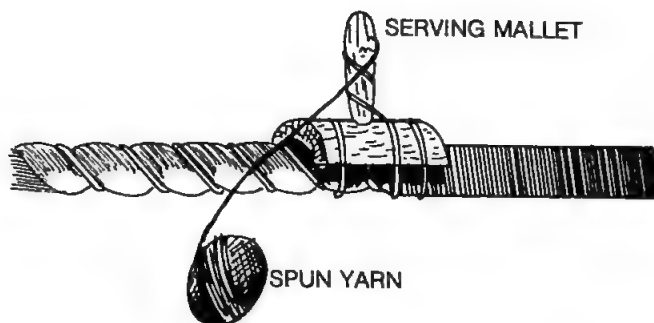
CANVAS STRIP

WORMING

Rope yarn is wound into the grooves between the strands.

PARCELLING

Canvas strips wrapped over the wormed rope.



SERVING MALLET

SPUN YARN

SERVING

Spun yarn or marline wrapped tightly over the wormed and parcelled rope.

SEIZINGS, SPLICES, KNOTS

Ropes were fastened to one another and to various elements of ship's gear in a large number of ways. The ends of all ropes were variously treated depending on the type of attachment it was to have.

A main or forestay, for example, had an eye at the upper end. The lower end passed through the eye as with a cowboy's lariat to form the loop for the attachment at the masthead. To prevent the eye from snugging up tight around the mast, a "mouse" or fat bump was woven into the stay as a stopper.

The lower end of the stay went around a heart and was "seized up on its own end" with a "round seizing."

Shrouds for the most part went double around the masthead, the two ends hanging down to the shipsides where deadeyes were turned-in. Since shrouds were often cable laid ropes (lefthanded) they also went lefthanded (counter clockwise) around the deadeye. They were seized to their own ends with throat seizings.

Shrouds were also turned into deadeyes "cutter stay" fashion.

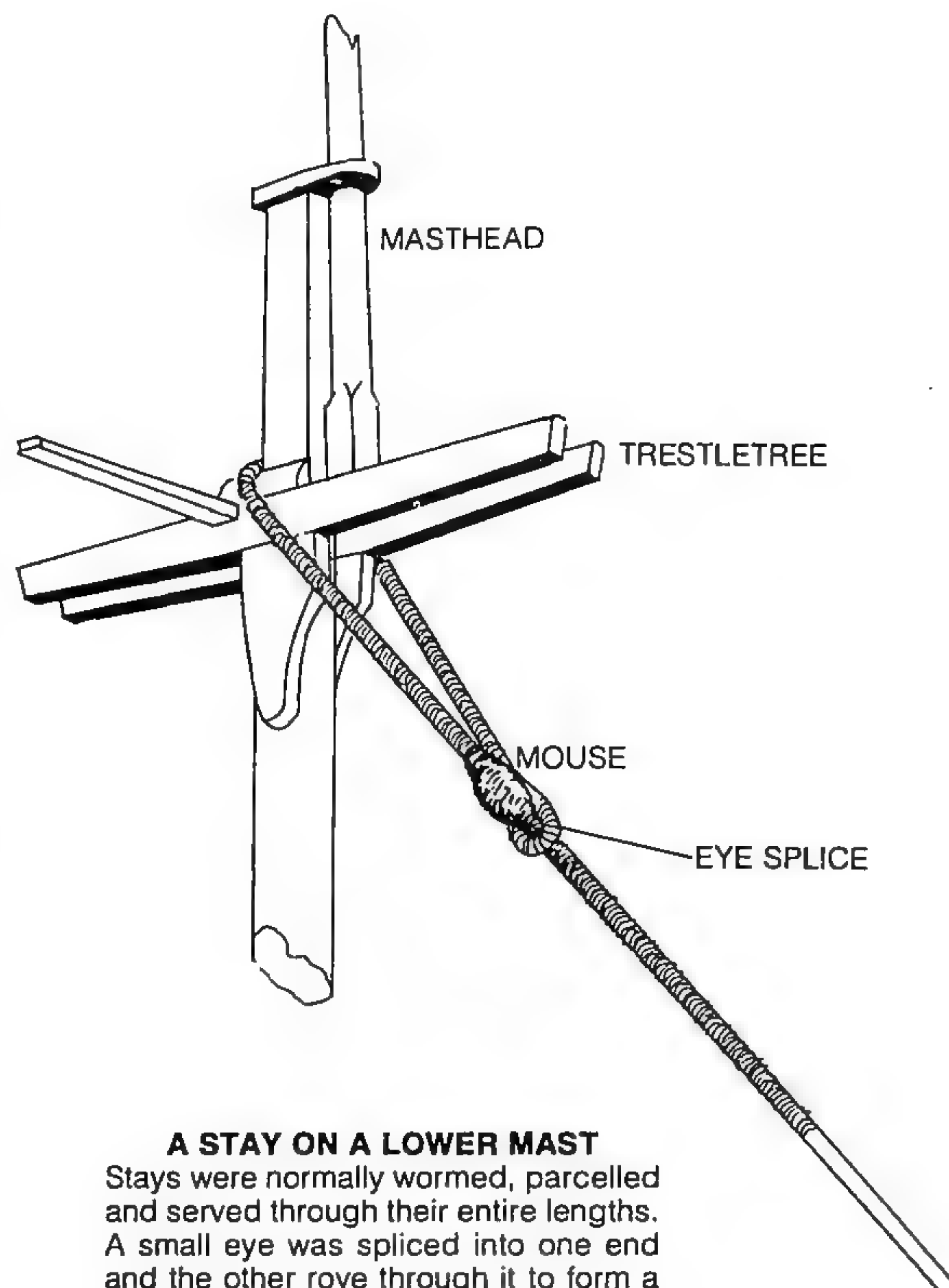
The stopping of blocks was another important element of ropemanship. The standard stop consisted of a short length of rope with its two ends short spliced together so that it made a ring. The ring went around the block and was made fast with a round seizing with riding turns.

A block set into an eye splice on one end of a line became a "tail block."

A clew line block was stopped in the bight of a short line with an eye splice in both ends.

Some stops consisted of a bight where one end was short with an eye splice in it and the other was long. Such a block might do for a quarter block.

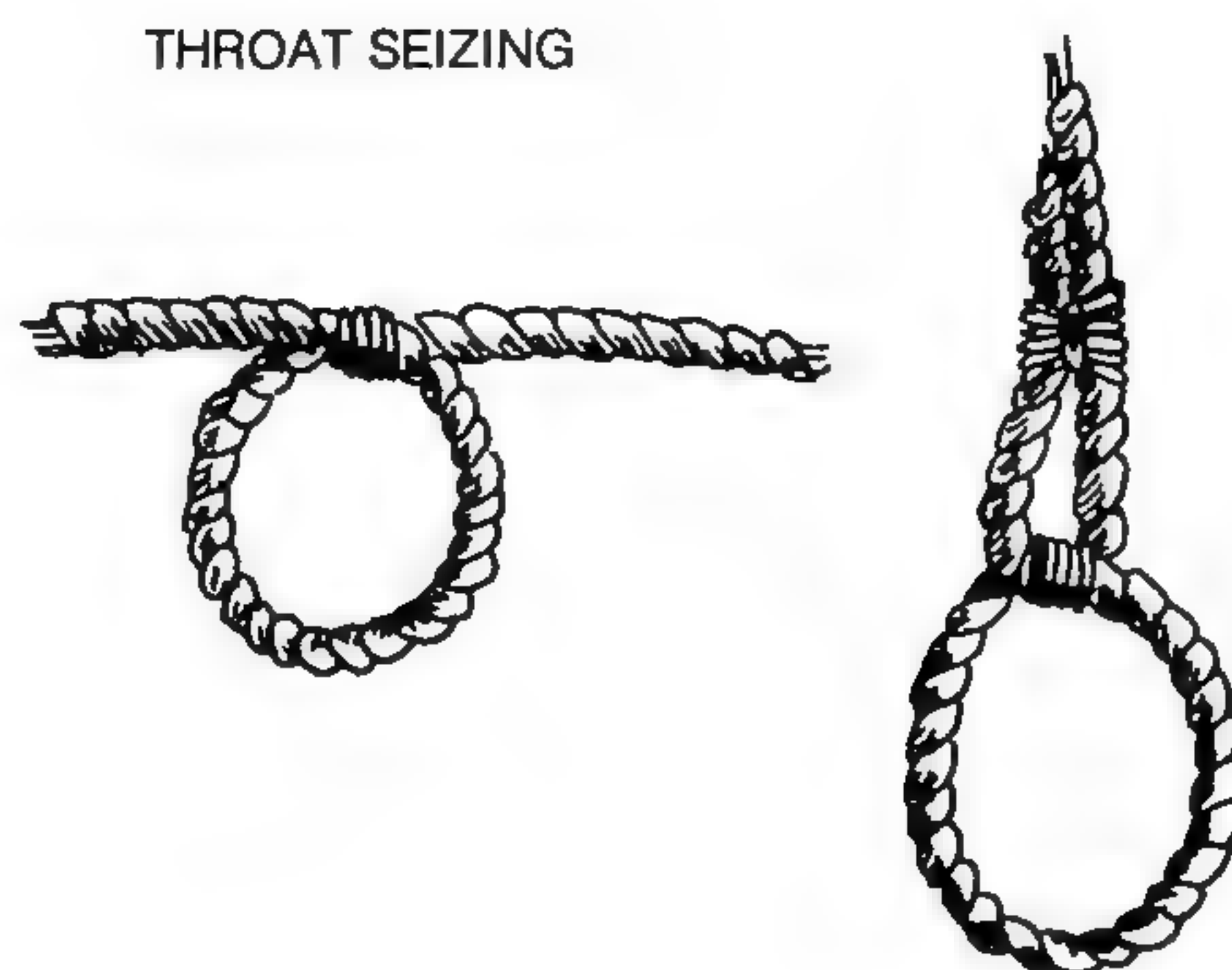
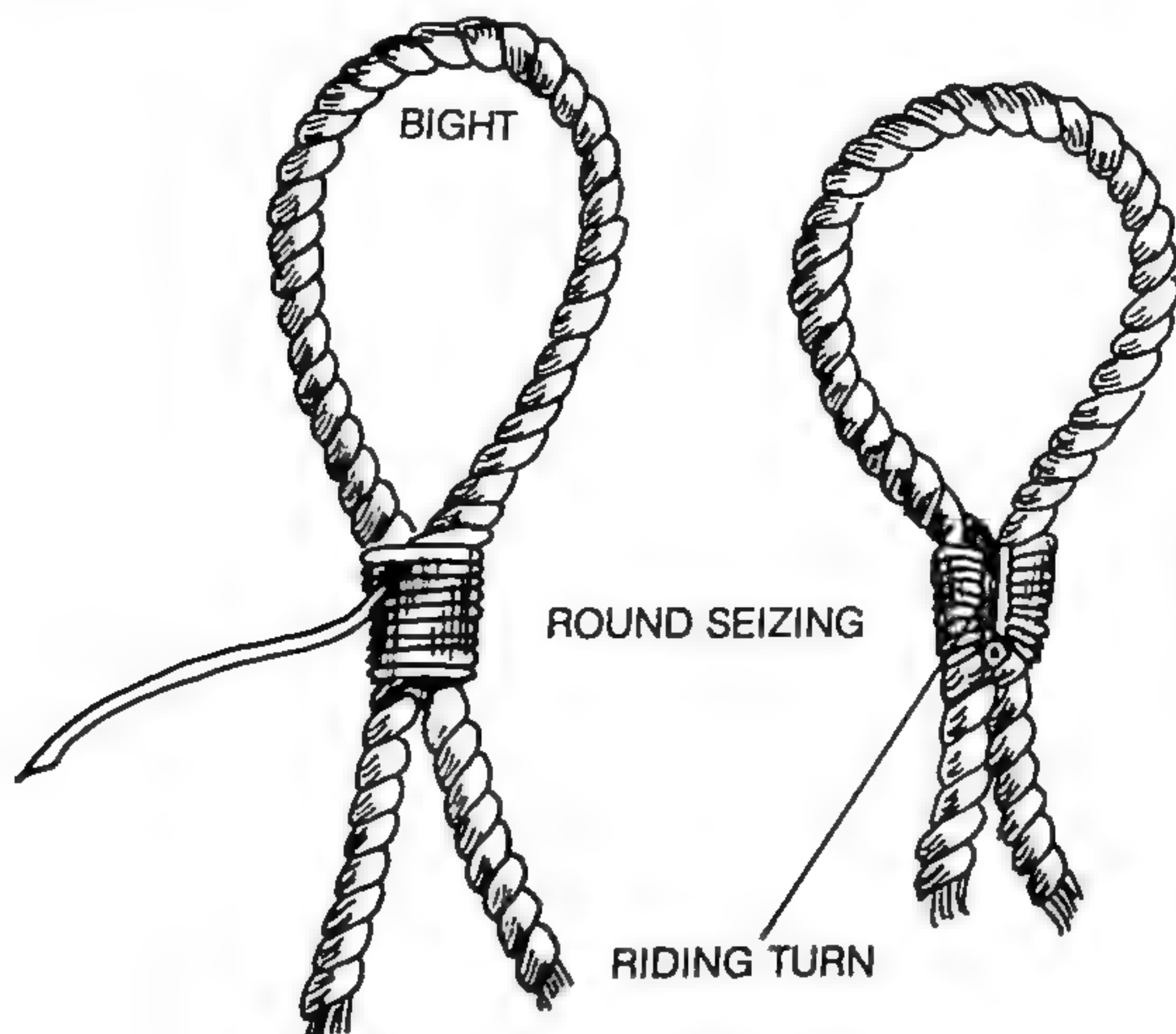
In all cases, the stops were wormed, parcelled and served except for the extensions of the long ends.

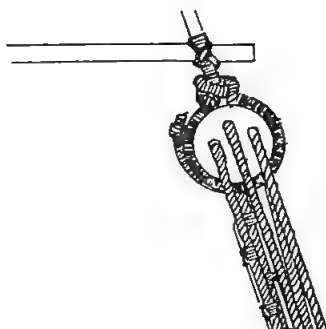


A STAY ON A LOWER MAST

Stays were normally wormed, parcelled and served through their entire lengths. A small eye was spliced into one end and the other rove through it to form a noose similar to that of a cowboy's lariat. The noose was stopped with a bulging piece of rope work woven into the stay called a mouse.

Shrouds are not shown. The stay in fact would be installed after the shrouds were in place and therefore would be above and over them as they go around the masthead.

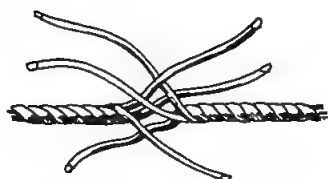




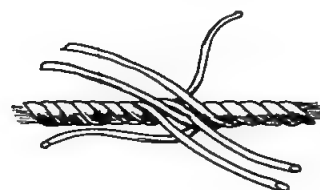
A Deadeye Turned in Cutter stay fashion



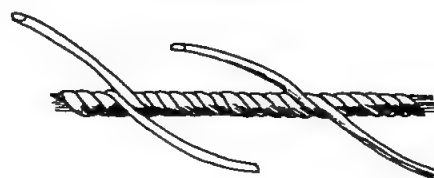
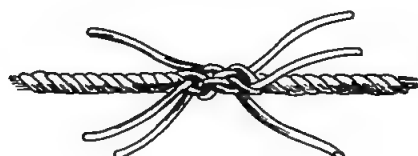
EYE SPLICE



SHORT SPLICE



LONG SPLICE



KNOTS

Secure Lines to Spars



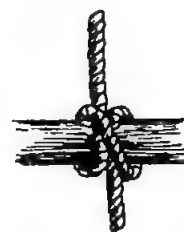
Timber Hitch



Magnus Hitch



Rolling Hitch



Clove Hitch

Secure Lines to Tackle Hooks



Cat's Paw



Blackwall Hitch

Secure Line Ends to Each Other



Carrick Bend



Sheet Bend



Bowline makes a non-slip eye



Figure 8 Knot



Overhand Knot



Square Knot

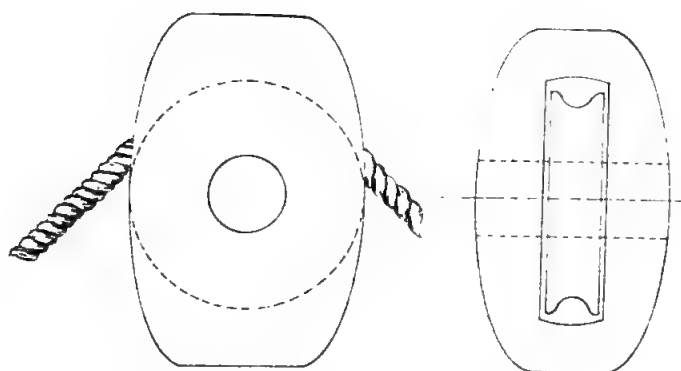
BLOCKS AND RIGGING HARDWARE

Blocks and other rigging hardware displayed great variety through the period of the sailing ship. Since little in the way of generality can be offered for this class of data, the modeller is advised to undertake some special research for a particular ship.

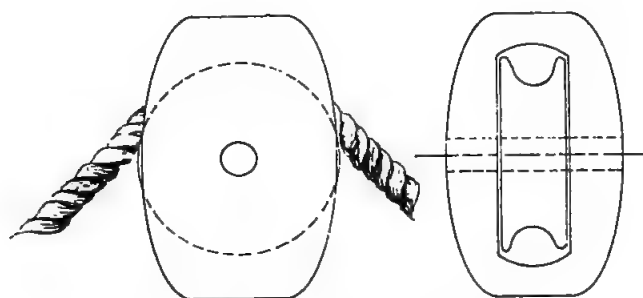
The size of a block was determined by its sheave size. The sheave size was a function of the size of rope it was to accommodate. Thus we find the diameter of 17th century sheaves specified as "2 $\frac{3}{4}$ times the circumference of the rope" which converts to about 9 times the diameter. Later in the 18th century the English specified blocks, of 6 times the rope diameter, while American ships fitted blocks of about 8 or 9 times. Other countries adopted slightly different ratios. Nonetheless, 17th century blocks were about 1 $\frac{1}{2}$ times as large as their later counterparts because the ropes were larger.

The early blocks were made entirely of wood, usually hard, oily *lignum vitae*, which fact dictated larger size. About 1750, Walter Taylor, an English block maker, introduced iron axles and sheaves making smaller blocks feasible and this inspired the new "6 times diameter" formula, which was found to be about the smallest sheave of practical use. Diminished sheave size yielded heavier work and sailors came to view ships with small blocks as "work houses." Hence Americans never lost their preference for larger blocks.

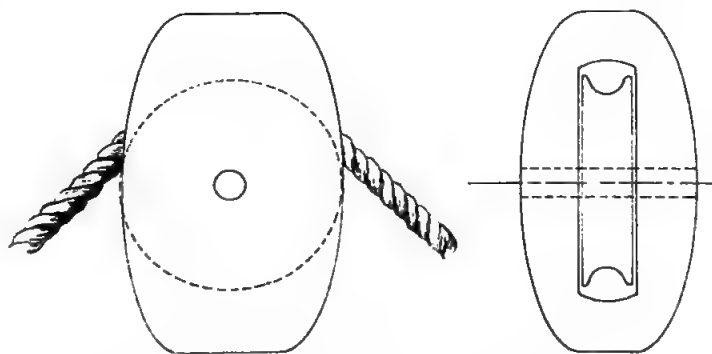
After 1850, iron blocks with internal iron strops came into use. Since these strops, unlike hemp strops, were rigid, the blocks had to be made with hooks facing in various planes. Becketts, shackles and other attachments were attached the same way or fitted with ball joints.



English — 1700 9 times diameter of line

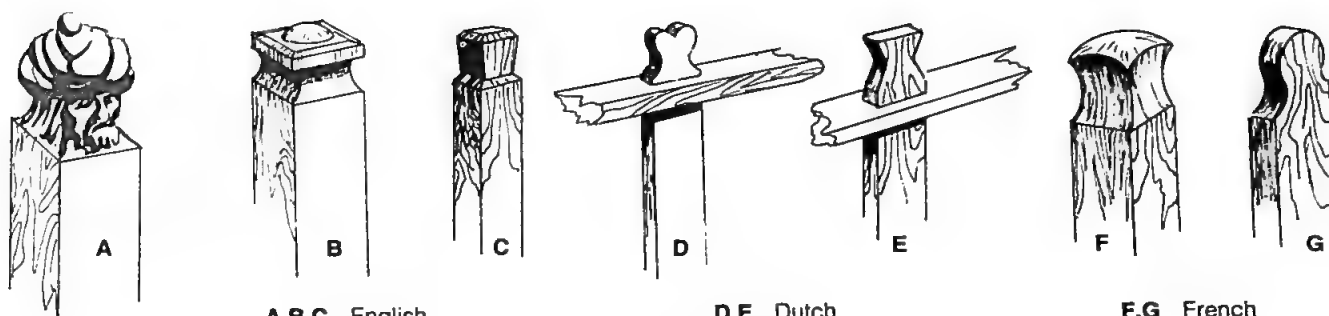


English — 1800 6 times diameter of line



American — 1800 8 times diameter of line

TIMBER HEADS



A,B,C English

D,E Dutch

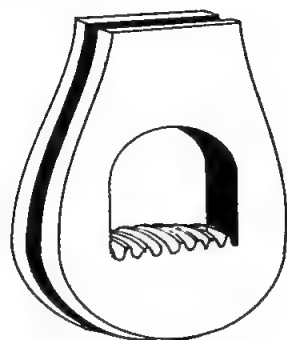
F,G French

Lines were tied off on the timber heads which were extensions of the ships frames or stanchions extending above the rails. The heads

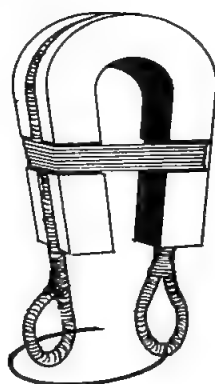
would be variously carved. Timber heads were a prominent feature of forecastle, quarter deck and poop rails on 17th and 18th century ships.

HEARTS

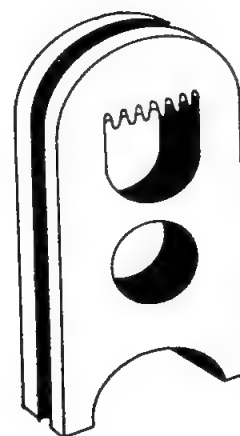
Hearts were important fixtures in the setting up of stays. Made of hardwood, they would be used in pairs, like deadeyes, laced together with lanyards.



CLOSED HEART



OPEN HEART

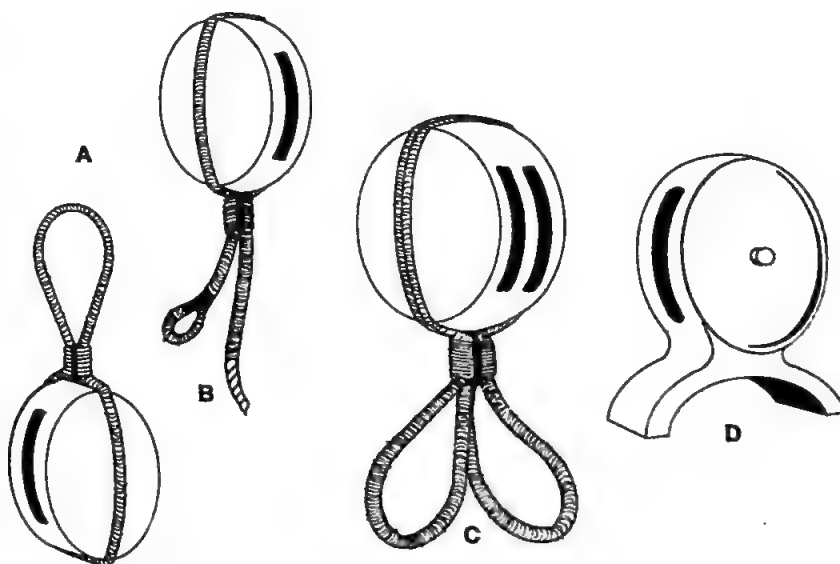


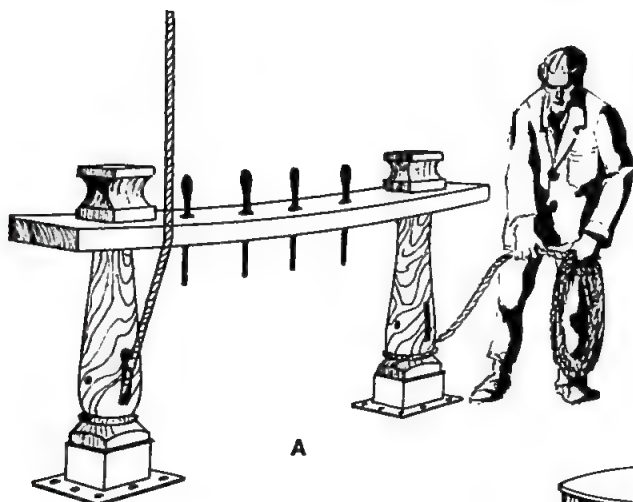
LOWER HEART FOR THE FORESTAY
with a hole for the jibboom and the lower edge
shaped to fit over the bowsprit

STROPS

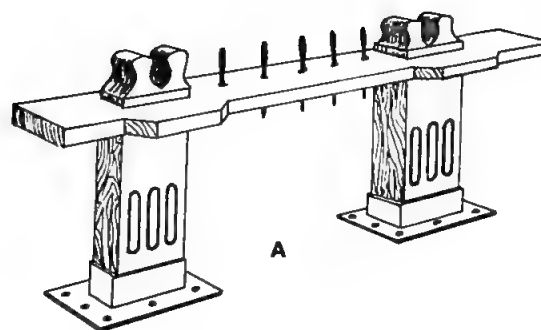
Blocks were variously stropped (strapped) with lengths of wormed, parcelled and served rope.

- A A single strop for a block was most common consisting of a hoop made by splicing the two ends of a short length of rope together. The hoop went round the block and was seized leaving a loop or becket for further attachment.
- B Long and Short End Strop might be used to fasten a block to a spar.
- C Double Stropped Block might have the two bights laced together around a spar.
- D Monkey Blocks were nailed to the top edge of a yard as leads for the buntlines.



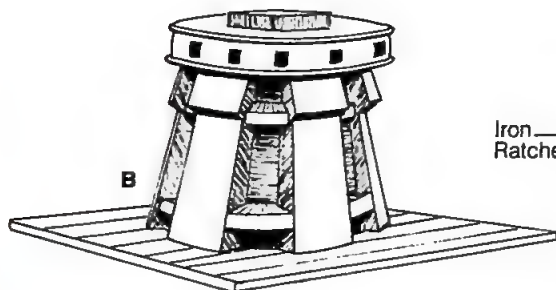


A

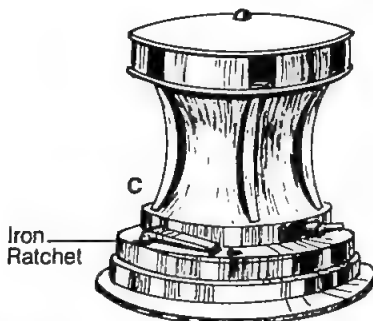


A

A Fine finished hardwood life rails on the Cutty Sark reflect the prosperity of the golden age of the China tea and opium trades as well as the pride of English and Scottish ship builders of the period, though. The Cutty Sark was built too late to earn her owners great riches.



B



C

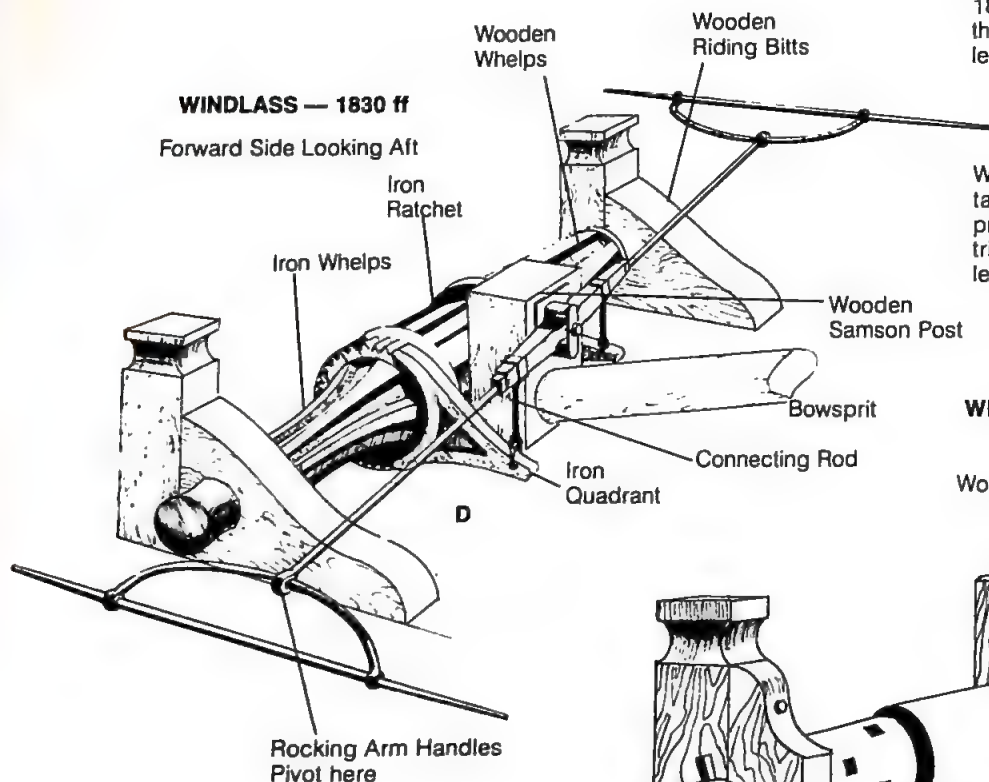
Iron Ratchet

B The barrels of early wooden capstans went down through two or more decks. Drum heads for the capstan bars and whelps were fitted to the barrel above each deck so it could be turned at the deck desired or on all decks at once. The capstan was vital to very heavy hauling jobs such as weighing anchor, raising topsail yards, or lifting guns from the hold.

C Cast iron capstans came into use about 1830. They worked by the same principle as the wooden ones, but more smoothly and with less friction wear.

WINDLASS — 1830 ff

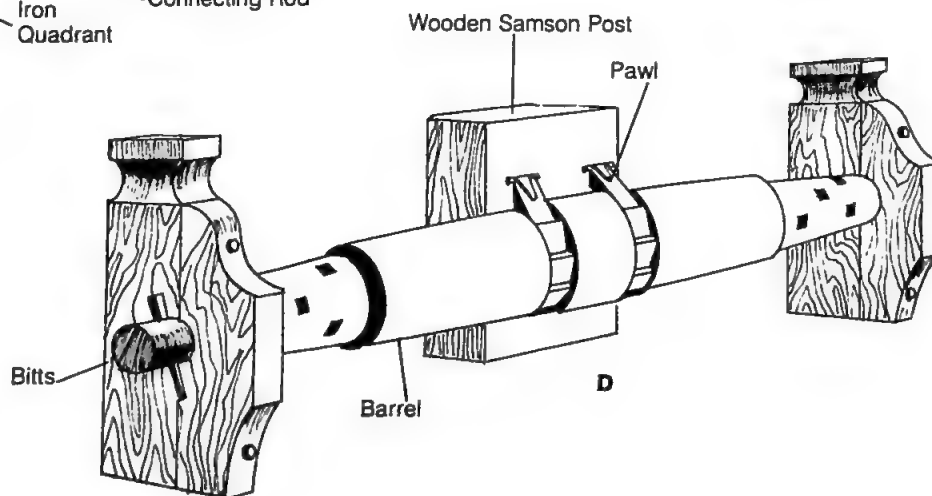
Forward Side Looking Aft



D

Windlasses performed many heavy hauling tasks including weighing anchors. They were preferred to capstans in that loads were distributed over a larger deck area and greater leverage could be obtained.

WINDLASS — 1750 All Wooden Parts



D

TACKLE

Sailors pronounce the word "taykle"; landlubbers "tackle." A tackle consists of a rope rove back and forth through a pair of blocks each of which may have one or more sheaves. The purpose is to gain mechanical advantage or purchase with a line. To increase purchase is to decrease the amount of effort required to move a load.

A tackle is similar, in principle to a lever. A lever works by having a long "effort arm" moved by a small force balanced against a heavy load on the end of a short "load arm." Thus, a small child on the long end of a teeter-totter can lift a heavy adult on the short end.

The fall of a tackle is equivalent to the length of the effort-arm of a lever. The amount of mechanical advantage gained with a tackle depends on the number of rope ends that begin or emerge from the running block. A gun tackle for instance, consists of two single blocks where two rope ends emerge from either side of the running block.

Hence for the same hauling effort one can lift twice as much weight with a gun tackle as he can without it.

A luff tackle has three rope ends emerging from the running block. The mechanical advantage is increased by a factor of three. The mechanical advantage of a "three" by "four" tackle is 8 times that of a straight haul since 8 rope ends (4 each side) emerge from the 4 sheaved running block.

The fall of a tackle is all the rope that is rove through the sheaves. It has two parts. The part that runs back and forth between the sheaves is called the running part. The part emerging from the last sheave and on its way to the hands of the hauler is called the hauling part.

The hauling part of a tackle may emerge from either the standing block or the running block, and the fall may originate on either of the two. If the fall originates on the running block and the hauling end also comes from it, both ends count in computing the mechanical advantage of the system.

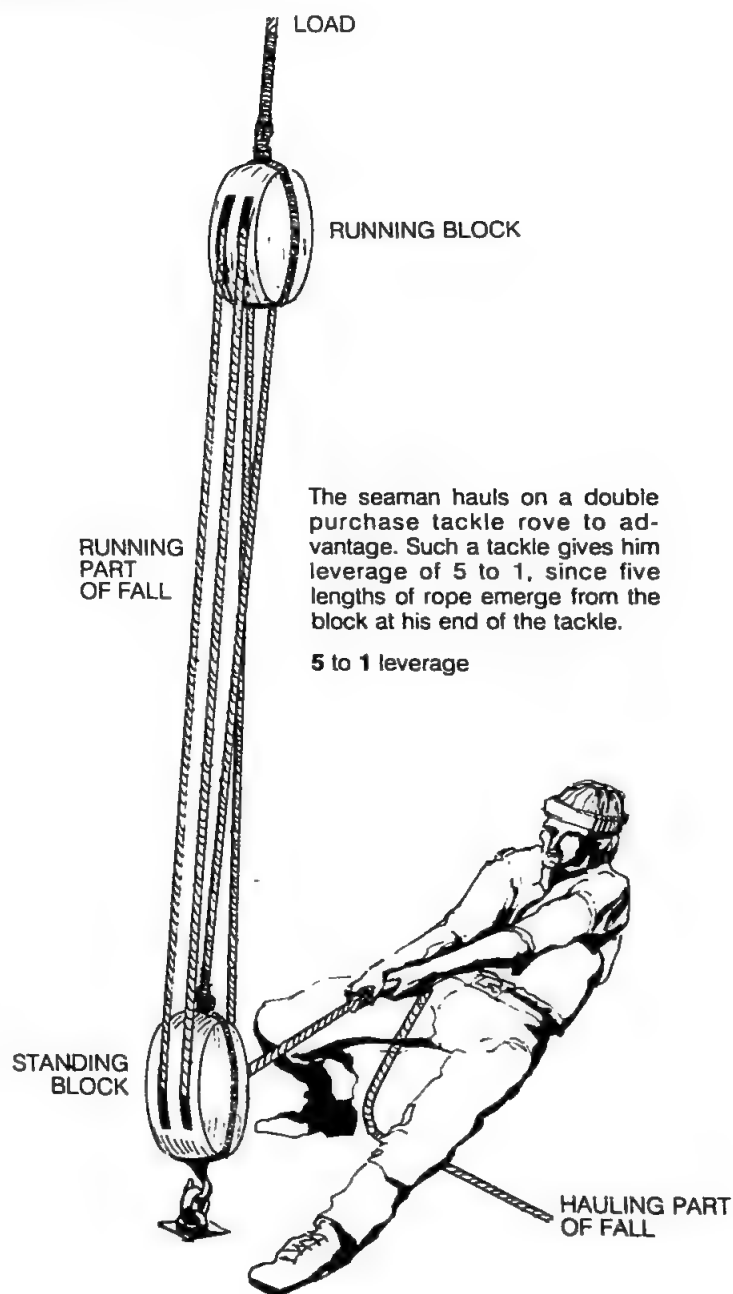
Therefore, a tackle may be either "rove to advantage" or "rove to disadvantage" depending on how many rope ends are made to come from the running block.

A given ship may have a large variety of tackles in her rigging: some rove to advantage, some not depending on whether the hauling end is convenient. Warships, because they had plenty of money and a need for speed, had a special standing tackle for almost every hauling job aboard. The frugal merchantmen, however, traded urgency for money. Often their practice was to equip their ships with a minimum number of portable tackles which could be shifted about as need required. Various these tackles were called "handy-billies" or "watch tackles."

Most of the hauling jobs on a sailing ship were handled with tackles made up of one or two sheaved blocks. Treble or four fold blocks normally were reserved for only a few very heavy hoists such as the main or fore jeers, or the main or fore topsail halyards. Catheads and boat davits might have three sheaves.

The treble or quadruple block tackles while powerful, were also slow and except where the load was immense and time of little object, these tackles were impractical.

After 1850, though, when several thousand ton sailing ships were on the seas more of the big tackles were in use.



MASTS

The dimensions, proportions and placement of the masts of a sailing vessel are perhaps the most important considerations in her rig. Raging controversy over the "correct" way to mast a ship has occupied shipmen for centuries.

PROPORTIONS OF MASTS

The proportions of the various masts on a ship were most often expressed as fractions of the dimensions of the main lower mast. The length of the main lower mast was expressed as a multiple of the ship's beam.

The fractions varied through history as well as with the size, type and nationality of the vessel. There were also rules for the thickness of masts, though these rules were less rigid than those for length because materials varied.

A mast made from a single trunk of fine spruce would be considered stout enough even though it fell short of the prescribed thickness. On the other hand, if a mast was built up from less desirable material and lashed together with woodings, the shipwright might insist on greater than normal thickness.

In this respect, it is interesting to note that one of the major reasons for England's interest in North America was its great store of tall, straight pines needed for masts. By the colonial period, England had all but used up her timber resources in ship building, so that to this day England is but sparsely wooded.

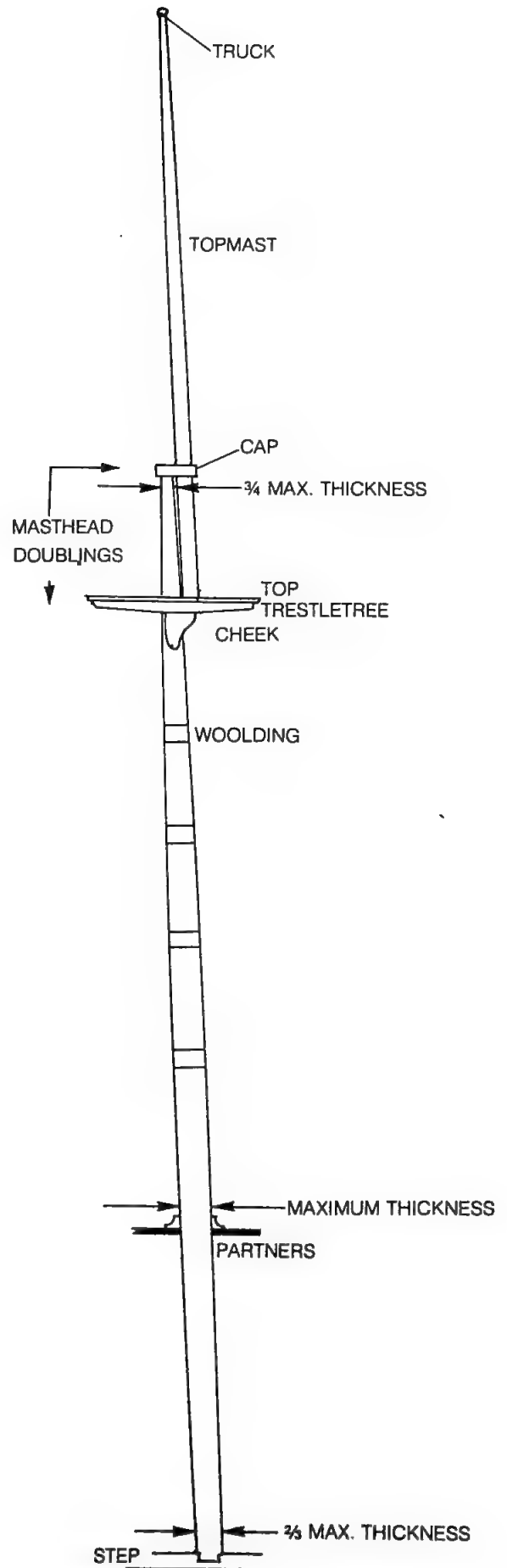
The lower masts tapered from thickest at the partners to thinner at the top and bottom. They were about $\frac{3}{4}$ as thick at the top and $\frac{2}{3}$ as thick at the bottom as they were at the partners. The taper followed the line of a large arcs tangent at the partners.

The upper masts tapered similarly except that there was no taper to the lower portions.

In cross section, the lower masts were square at the step, octagonal up to the partners, round up to the cheeks and square at the trestle trees and round from there to the cap.

The upper masts were square from the fid up to above the top, then round up through the cap to the next doubling.

The mast doubling varied in length. In the early years of 1600, the upper masts were lighter and carried less sail so that the masts required little overlap. As time went by both topsails and topgallants grew bigger and the mast couplings grew longer commensurately.



MAST PLACEMENT

In principle, the placement of masts in a hull depends on where one decides the sails should be to obtain optimum sailing performance. Generally, this means that somewhat more than half of the total sail area will be set forward of the hull's center of gravity. Such an arrangement has the sails always pulling the ship forward. The alternative would have the sails always pushing the stern around.

But if the sails are too far forward the ship becomes unmaneuverable. The answer lies in finding the exact spot where the ship will maintain a steady forward course under various sail settings, yet still respond favorably to the helm.

17th CENTURY

The ships of the 17th century were built rounder forward, more slender aft, with the result that their centers of gravity were considerably forward of amidships. Their rigs therefore were concentrated forward.

The mainmast was stepped at or a few feet forward of the center of the keel. The foremast was stepped on the stem at a point just below the waterline. The mizzen when it was single was stepped a little forward of halfway between the taffrail and

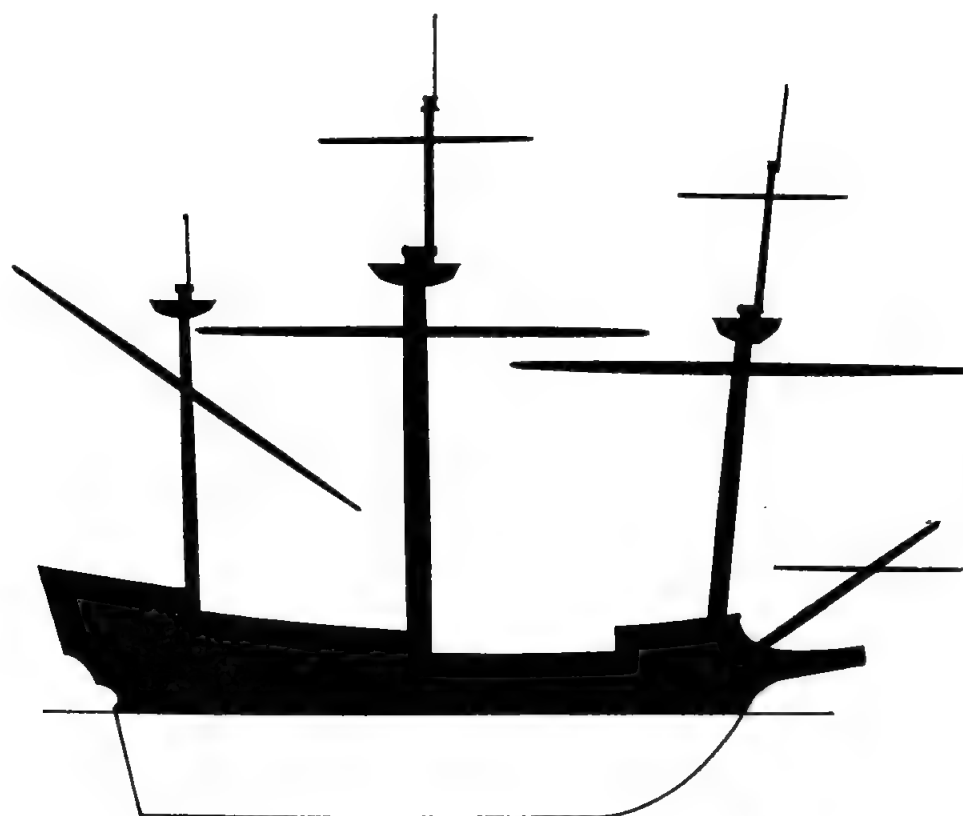
Every ship is unique and many a skipper has ordered his masts re-stepped because the builder had failed to find the "right spot" initially.

Captain Woodes Rogers, for example, tells us in his log dated August 11, 1708. "We lengthened our Mizzen-Mast four foot and a half, by placing it on a step on the gun-deck; got our fore-mast forward, and did what we could in order to be in a better trim than before. . . ."

The modeller, of course, is less concerned with sailing a ship than he is with duplicating the way the builders built it, but it is well to be aware of the reasons behind the shipwright's decisions.

the main. The bonaventure mizzen, as a fourth mast of the period was known, was stepped so that the sheet of the lateen sail was just inboard of the taffrail while the main mizzen (when the ship had a bonaventure) was moved forward. The bowsprit ran out forward beside the stem and a spritsail topmast was stepped on its most forward end.

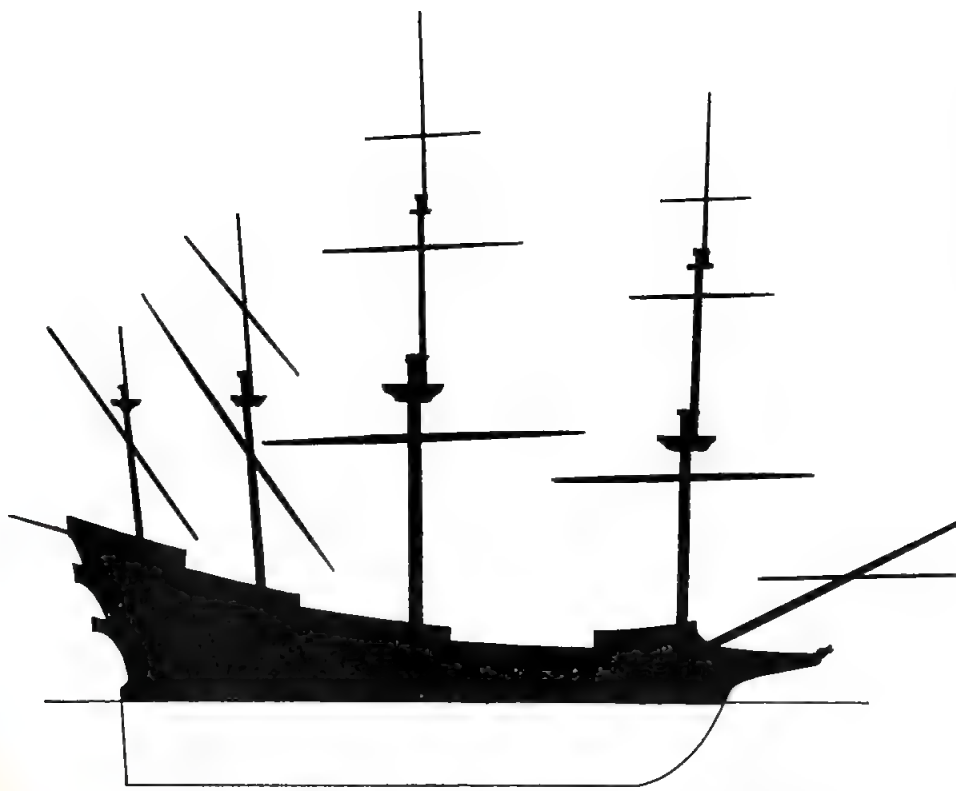
Given this it is easy to see that the sum of the sail area forward is quite a bit more than that aft where almost all of the latter is taken up with the lateen mizzen "steering sails."



17th CENTURY

MAYFLOWER - 1620

The "Mayflower," the ship of the Pilgrim fathers, illustrates the typical rig of small ships of the era. The main mast steps at the center of the keel; the foremast is well forward and raked forward. The topmasts are small while no sails were set on the flagstaffs above them.



EAST INDIAMAN - 1650

The formation of the East India Company in 1600 inspired the rapid development of ever larger merchant ships. The profile below illustrates the growth. The topmasts grew topgallant masts; the mizzen sported a lateen topsail and a fourth bonaventure mizzen mast was added.

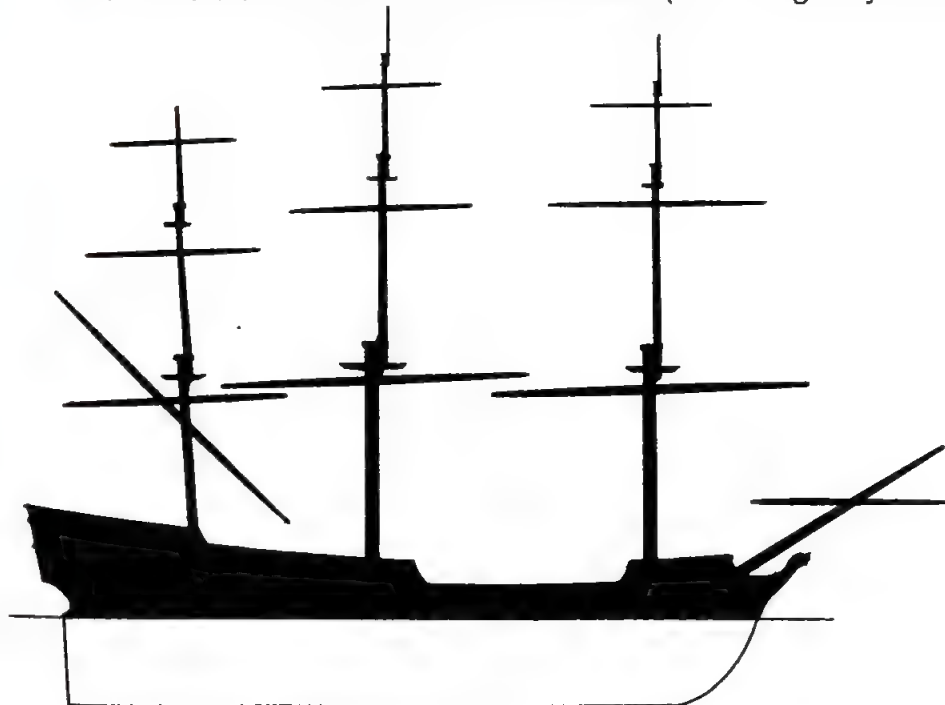
18th CENTURY

18th Century hulls underwater varied little from those of the 17th. The center of gravity still tended to be forward though not as far. But the high stern castles of the earlier century were cut down and so reduced the sail-like windage of these structures. The masts moved aft.

The main mast moved aft of the center of the keel and the foremast moved aft to the point about where the stem and keel met. The mizzen (the

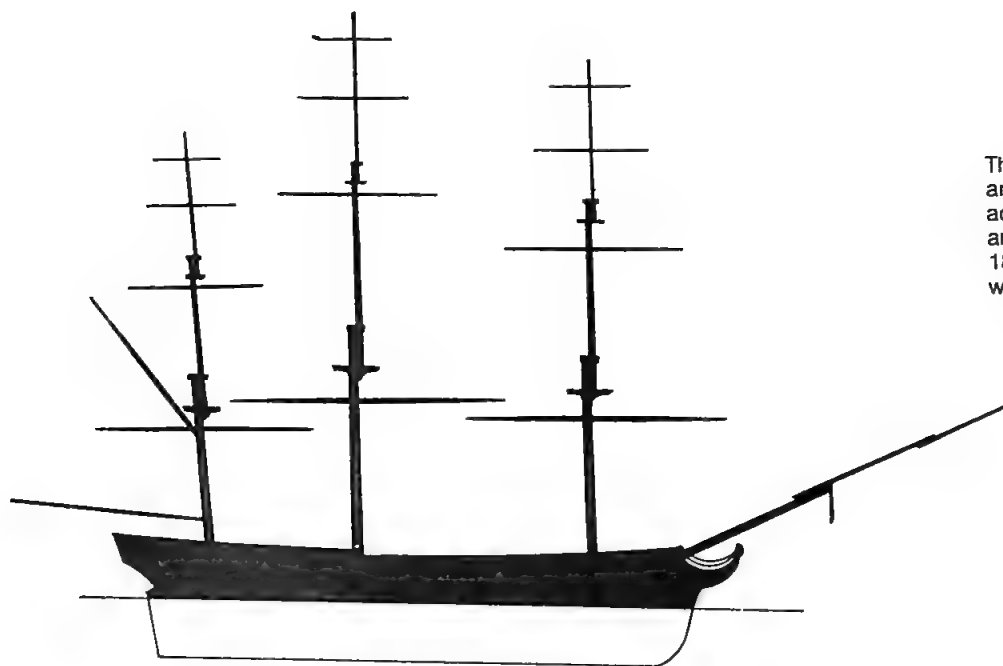
bonaventure was not in use at this point) stayed where it had been earlier.

The space between the fore and main masts was filled with staysails and the bowsprit was extended almost half the keel length or more before the bow and loaded with jibs and fore staysails. In spite of the more aft placement of the fore and main masts, the balance of sail was still forward of the center of gravity as it had to be.



BRITISH 3RD RATE - 1725

Main and foremasts moved aft through the century and the bowsprits longer. The mizzen was rigged with a topsail and topgallant sail.

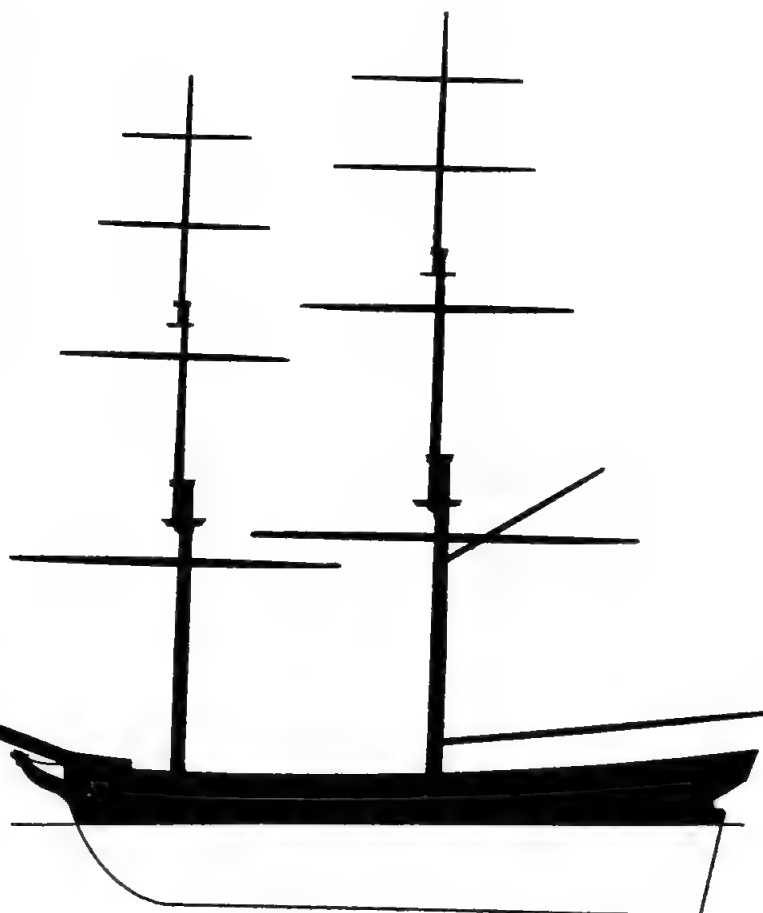


U.S. FRIGATE - 1812

The ships of the American Revolution and into the early 1800's were characterized by their extremely high rigs and very long head spars. During the 18th century the lateen mizzen gave way to the gaff headed spankers.

19th CENTURY

Hull lines changed dramatically about the middle of the century with the coming of the clipper ships. With them we find the center of gravity moved aft to a point just forward of midships and the masts moved even further aft to accommodate the new hull plan. The main mast is now considerably aft of the mid-point of the keel and the foremast is a third of the way between the forefoot and the main mast step. The mizzen is halfway between the main and the taffrail. Though headsails abound, the bowsprit is considerably diminished to less than a quarter of the keel length.



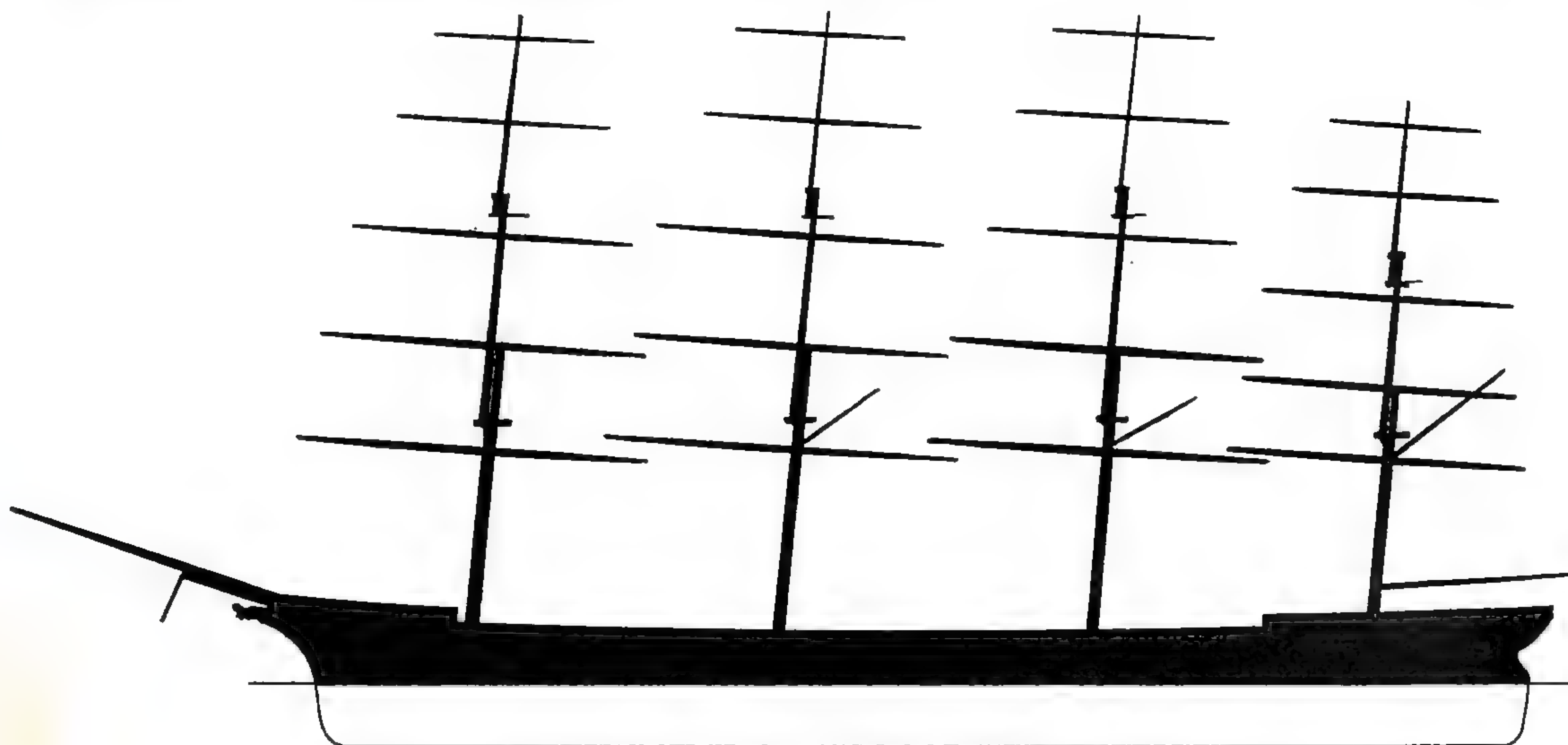
BRIG - 1825

The early 19th century witnessed the development of the packet ships, forerunners of the great clippers of the 1850's. The ships like this brig carried enormous areas of sail while hull design favored a sharp entry and run, soft chines and steeply rising floors (pronounced 'V' bottoms) all in the interest of speed. These early "clipper" designs while fast were also dangerous.

Earlier ships carried only a single lateen sail on the mizzen. The clipper ships replaced the lateen steering sail with a gaff headed spanker and crowded square sails above it.

The American fishing schooner reached a magnificent level of efficiency in this century also, and illustrates further the correlation between hull and rig. The center of gravity of the fishing schooner

compares with the clippers. In fact many schooners were designated as "clippers." The mainmast is stepped forward of the center of gravity and the foremast about halfway between the main and stem. The main sail is huge, bent to a boom that overhangs the stern a quarter of its length. The foresail and headsails are diminutive by comparison.



FOUR MASTED FULL RIGGED SHIP - 1880

The great clippers of the 1850's finally evolved into the giant windjammers which, like super novae, announced the end of commercial sail.

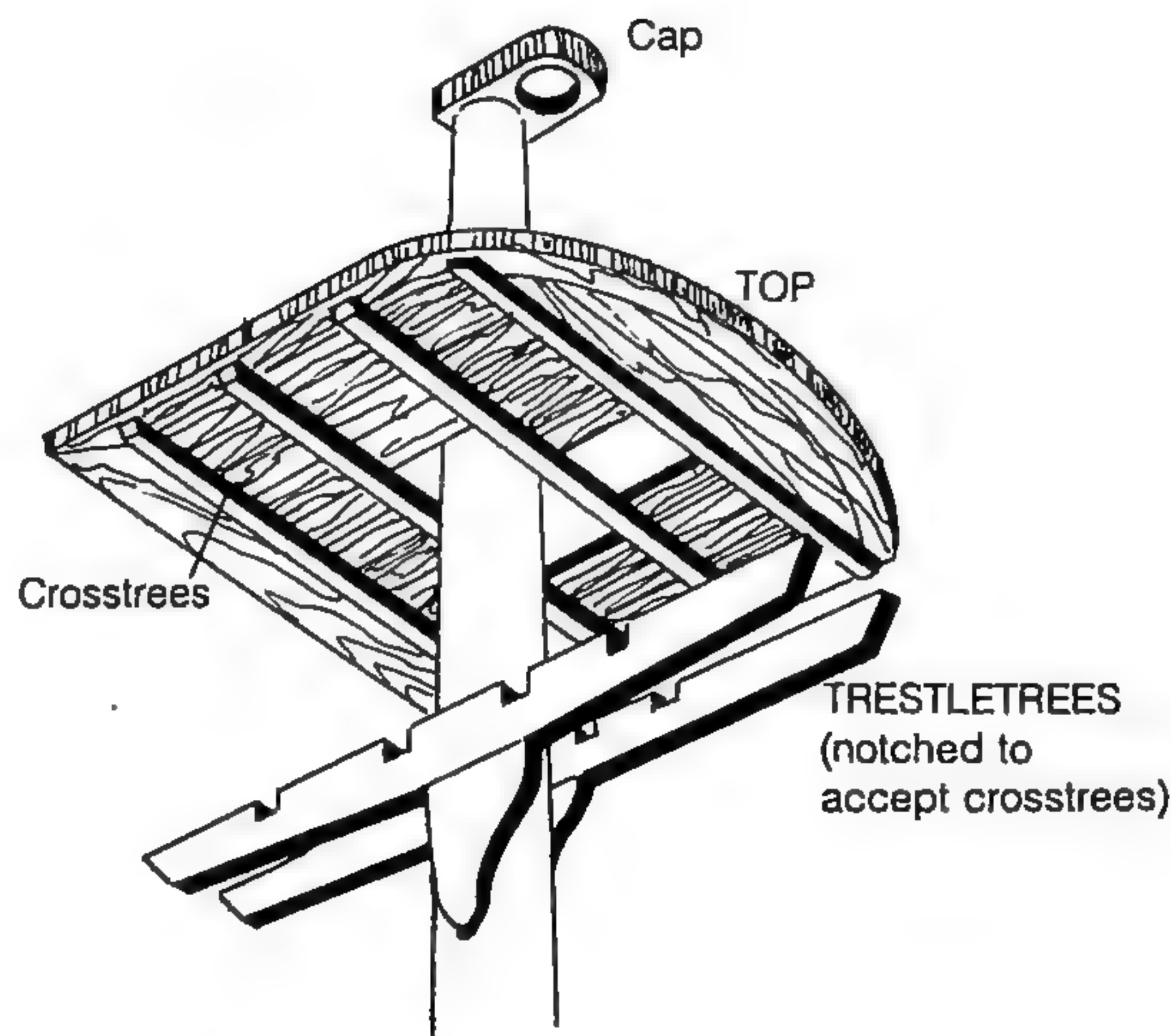
TOPS AND OTHER STRUCTURES

The design of mast tops, as did other ship elements, changed through the centuries. Few features, however, are as apparent as the tops for clues to a ship's period.

Up to the end of the 15th century, tops were thought of as fighting platforms. Naval warfare in the medieval centuries was a case of a limited number of mariners taking a large contingent of land soldiers to sea and bringing them into hand-to-hand contact with the enemy. Ships were viewed as water born siege engines.

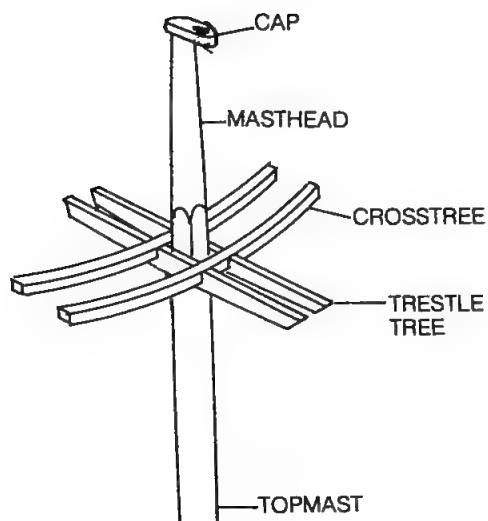
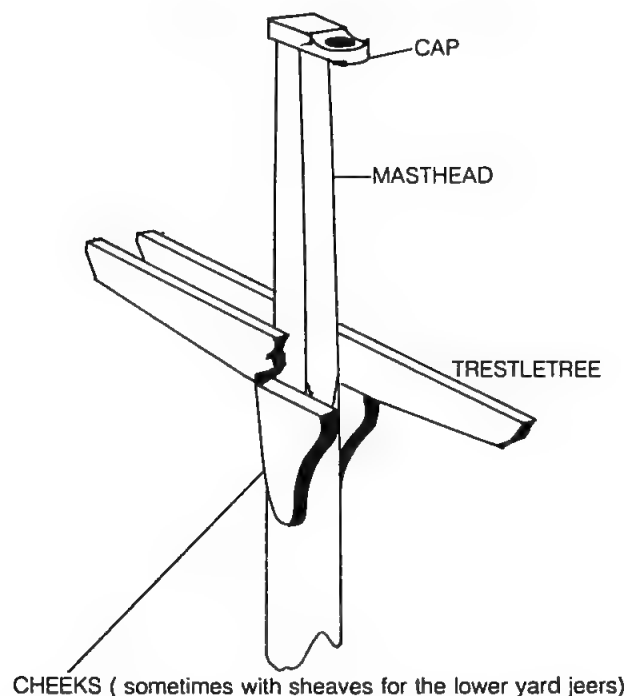
The top at that time was a battlemented "castle tower" from which archers could fire down on their foes, and from which rocks, hot oil and other missiles could be poured down. The platform was round with heavy sides built up so that it resembled a wooden tub.

During the 16th and 17th centuries we see a steady development in the use of guns. The warship was now designed as a gun carrier and the tops changed to accommodate the new role.



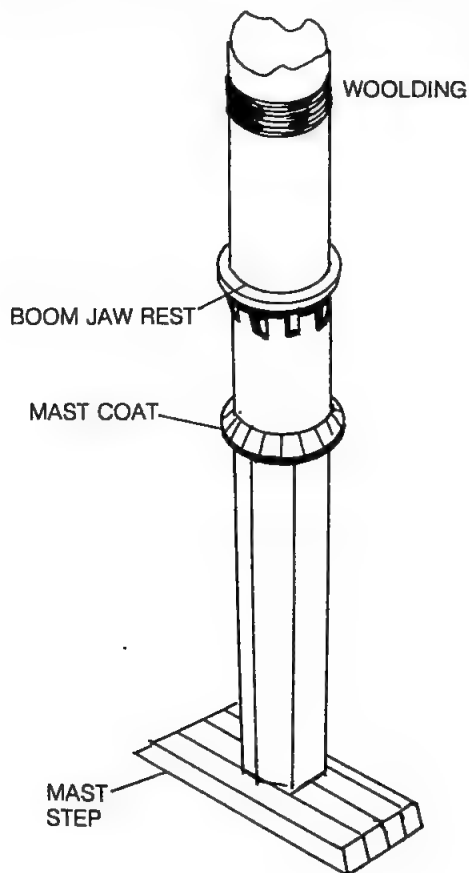
Tops were secured to the cross-trees and the whole unit put over the mast to nest into the trestletrees secured to the mast.

A typical lower mast is shaped like this

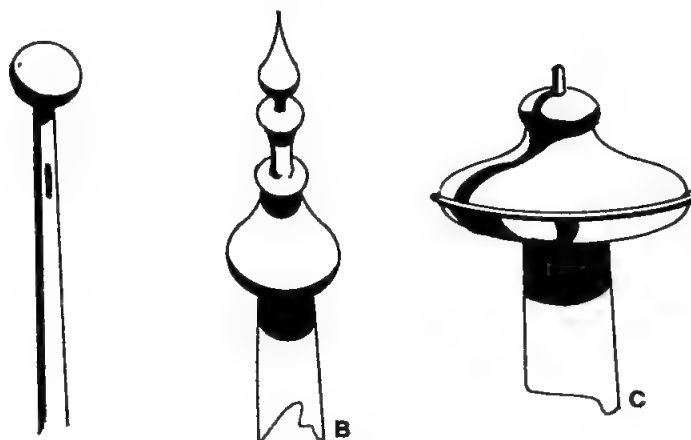


CROSSTREES

Topmasts and sometimes top-gallant masts were fitted with crossrees to spread the shrouds of the masts above. Similar in construction to the trestletrees and crossrees of the lower masts, the crossrees generally had no 'tops.'



TRUCKS



The very top of the highest masts were capped with "trucks" some times fitted with sheaves for flag halliards. 17th century trucks (B and C) were decorative turnings.

The first feature of the medieval tops to disappear was their high sides. In the 1600's they dropped to about knee height; in the 1700's they were at most six or eight inches. By the 1800's, the sides had diminished to the thickness of a plank.

In size the tops varied with the height of the topmast. When topmasts were small in the early 1600's the diameter of tops was about 25% of the ship's beam. By 1700 they had expanded to about 1/3 of the beam in diameter.

16th century tops, as we have said, were round and this configuration held up to about 1750, after which they became 'D' shaped.

Up to 1800 the top still had value as a fighting platform aloft. After that date the latter function declined in importance, leaving as the sole purpose for the top the spreading of the topmast shrouds and the support of other upper rigging.

The basic construction of tops, regardless of shape, followed similar principles throughout the sailing ship era. Just under the top the mast was fitted with cheeks over which were mounted trestletrees. The trestletrees consisted of two beams, one on either side of the mast in the fore and aft plane.

The basic frame of the top consisted of the crosstrees, two or three beams in the thwartship plane. The trestletrees were notched on the upper side to take the crosstrees.

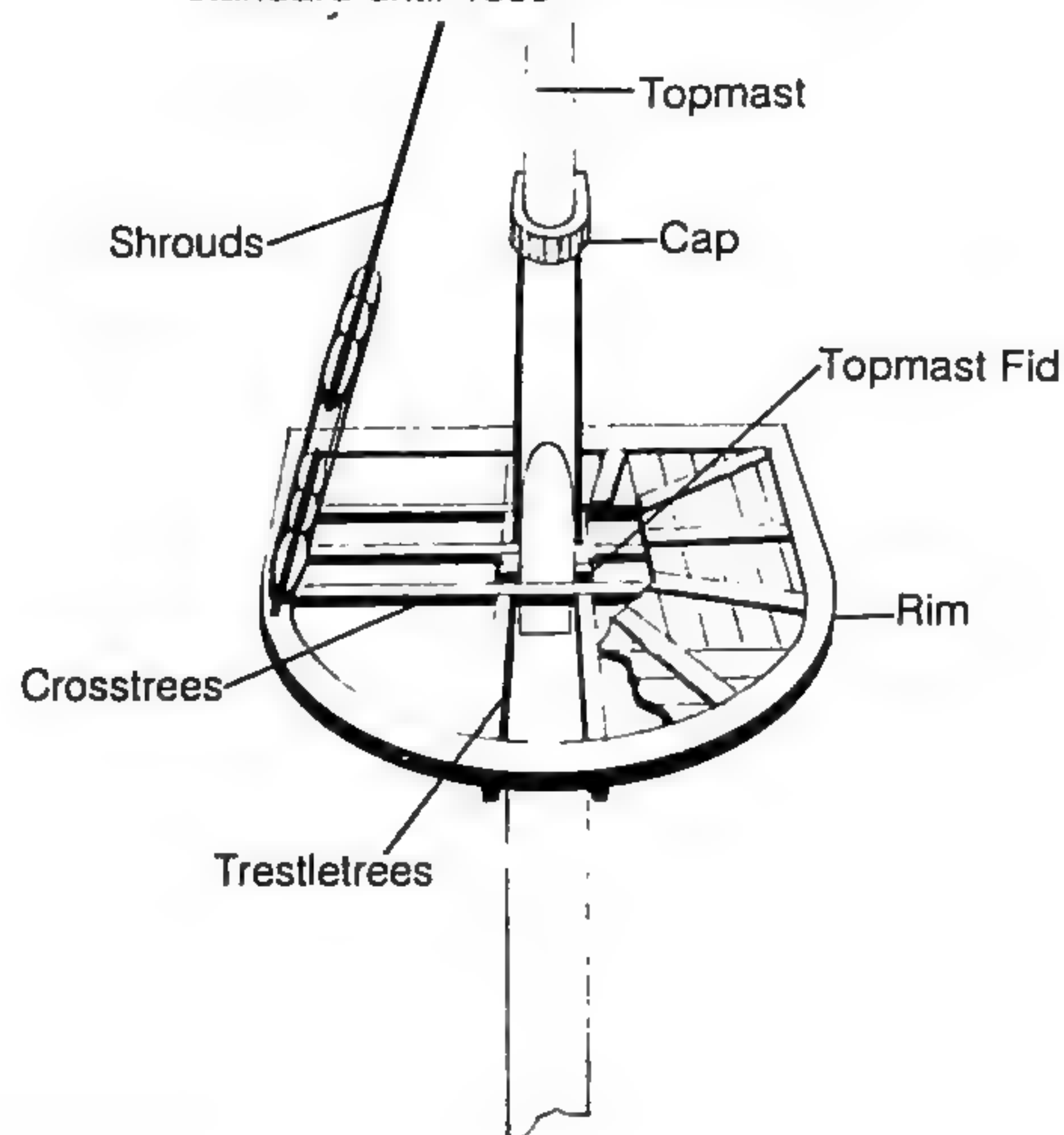
The crosstrees and trestletrees together formed a criss-cross underpinning that led out to the inner edges of the top's rim. The balance of the structure

was variously planked over depending on the shape of the top and the type of vessel it belonged to.

The tops of naval vessels were solidly planked like decks except for a single "lubber's hole" at the center. Merchant ship tops were lighter with grating-like planking, and had a pair of lubber holes, on either side of the mast.

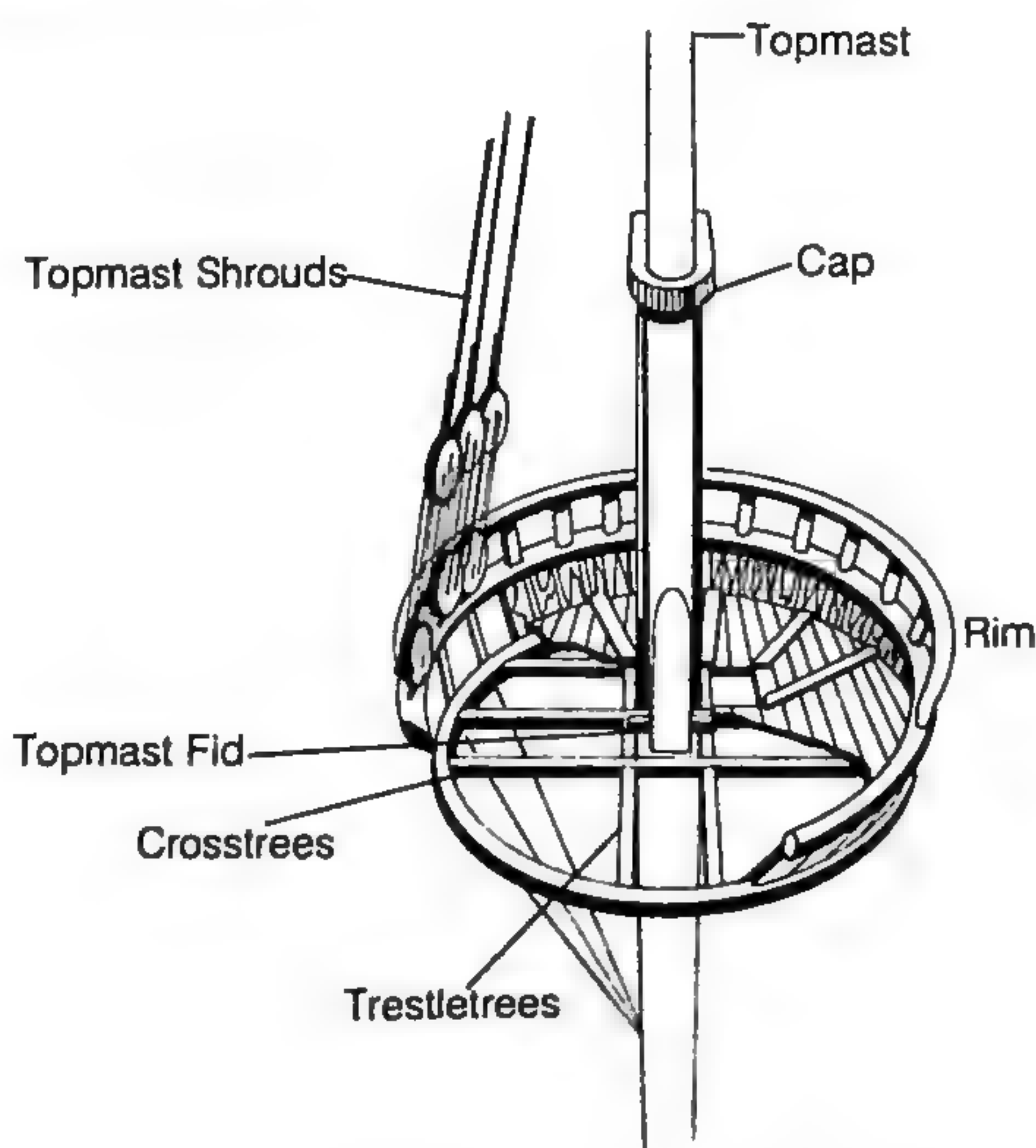
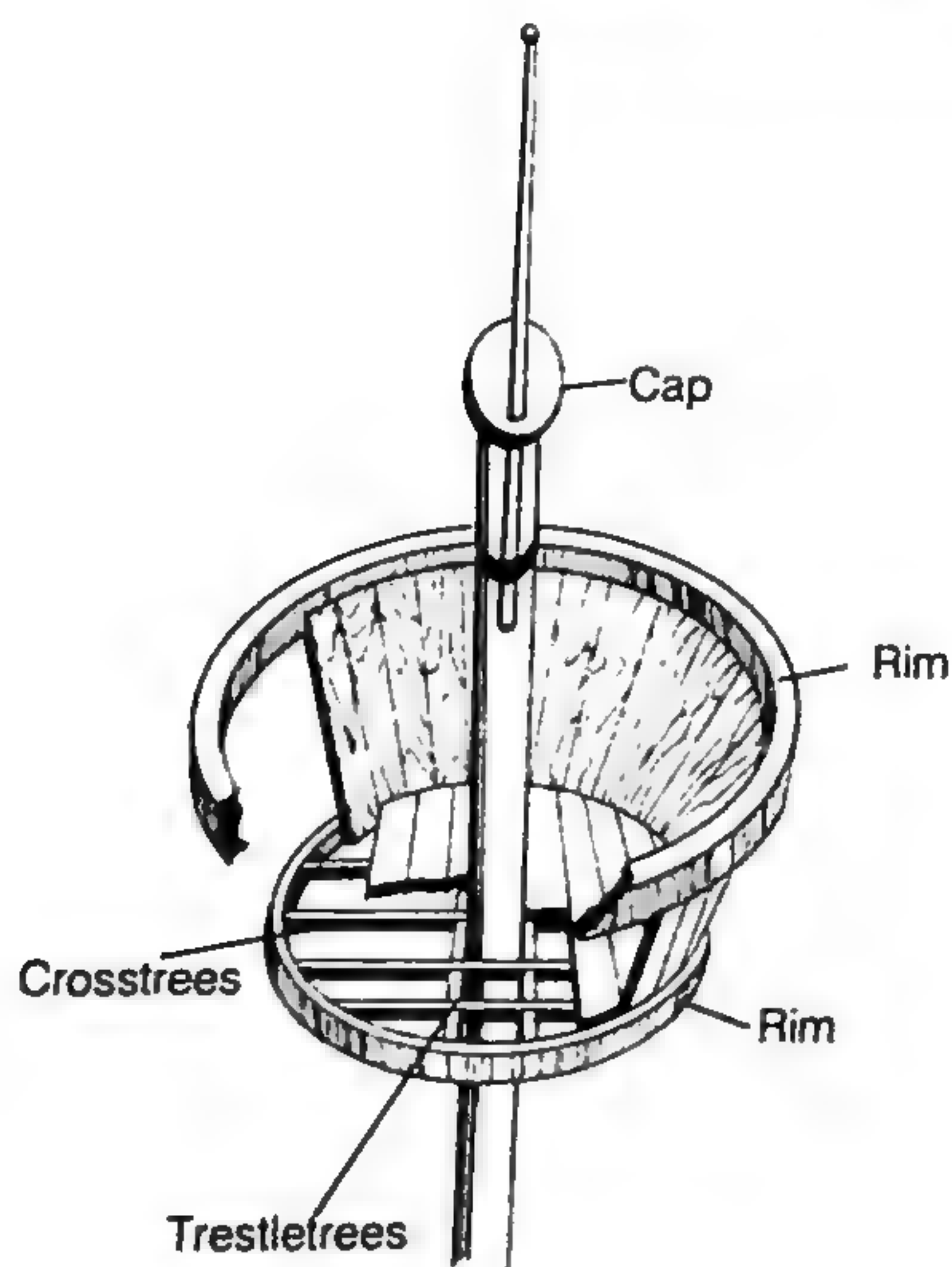
The lubber holes provided access to the tops inboard of the futtock shrouds.

18 TH CENTURY 'D' SHAPED TOP
standard until 1850



MID 17th CENTURY ROUND TOP

Early 17th century round top sometimes planked in; other times left as an open, basket-like structure.



Two views of the main top of Henry Bridenbecker's model of the brig "*Irene*." The '*Irene*,' originally commissioned by the English in 1806 as the '*Grasshopper*' and later captured and renamed by the Dutch, was typical of small men-of-war of the period.

Above: the futtock shrouds carry the thrust of the topmast shrouds down from the outer edges of the top to their connection on the futtock staves lashed across the lower shrouds. Catharpins tie the two futtock staves together.

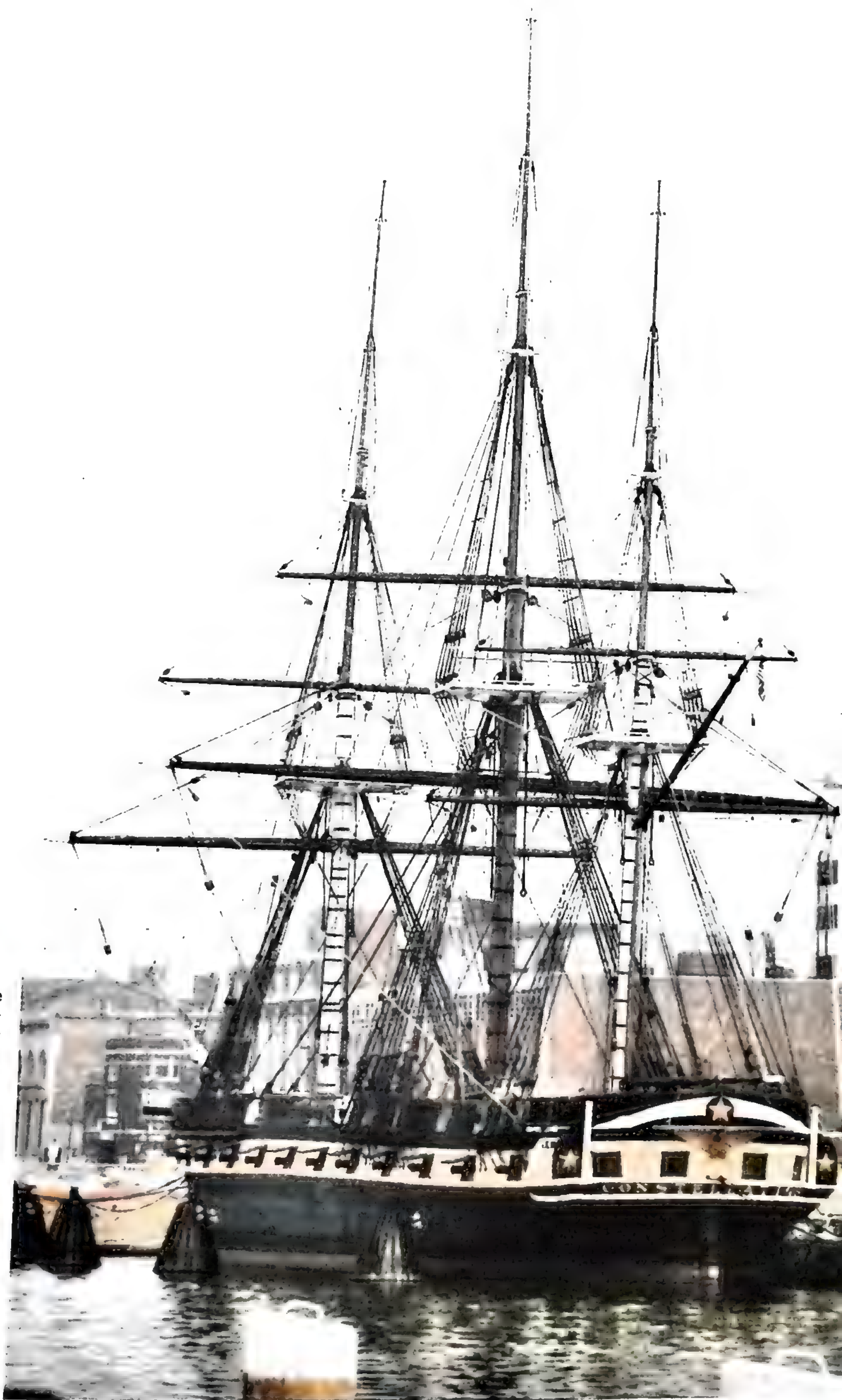
The diagonal spar in the foreground is the gaff of the trysail.

Note the unused ring bolts under the forward edge of the top. With sails set, these ring bolts would support buntline leading blocks.



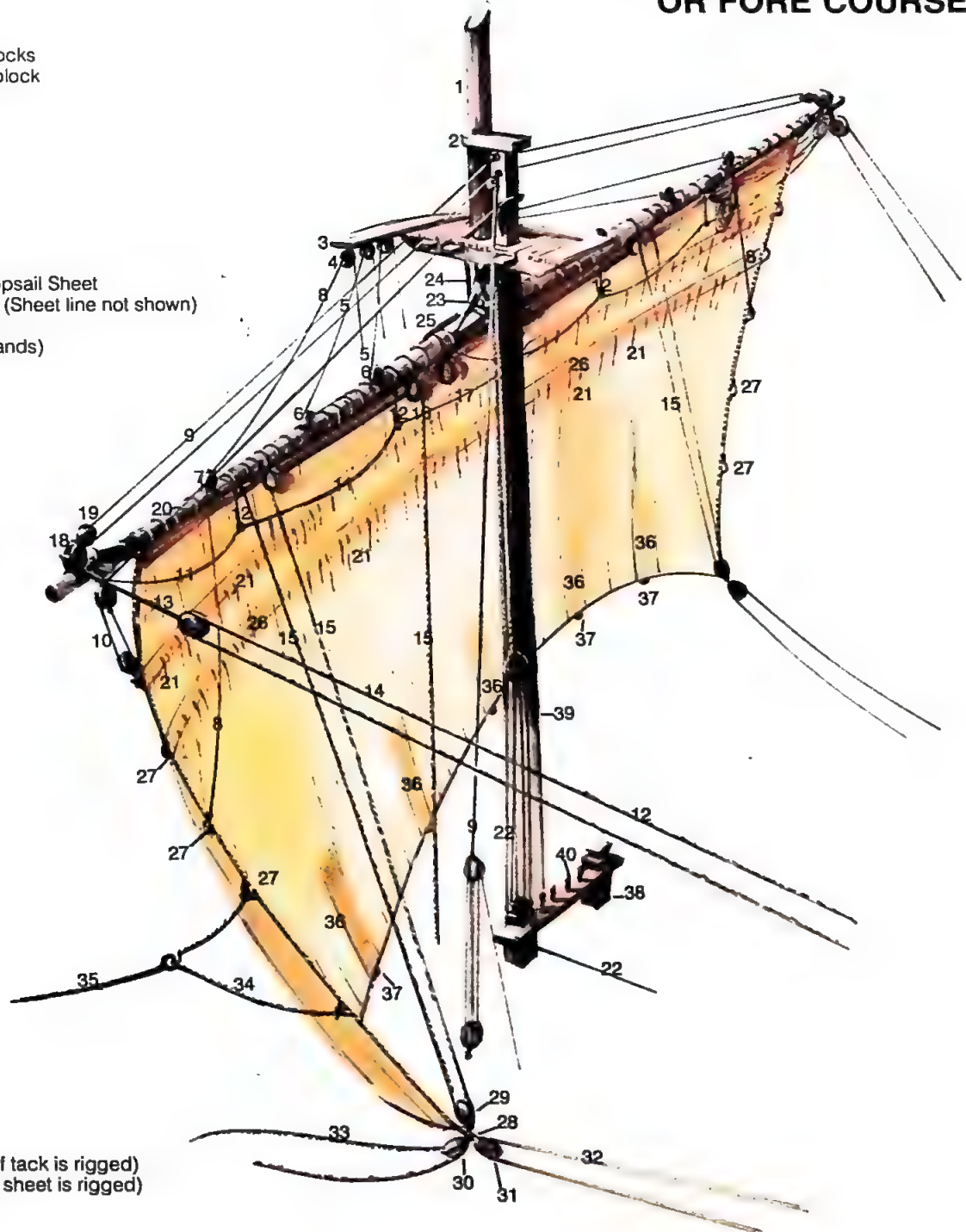
Below: This view clearly illustrates the mouse on the mainstay; the lead of the main yard slings up through a hole in the top and around the mast some distance up the masthead. Note also the radiating battens on the upper side of the top.

Frigate U.S.S. *Constellation* as she appears today in Baltimore undergoing restoration. Built between 1794 and 1798, the *Constellation* was among the first six ships commissioned by the U.S. Navy. She remained in active service for 87 years, finally retiring in 1881. During her long career she underwent a number of remodellings. When this photo was taken, only her lower and topsail yards were in place. The restored rigging reflects later 19th century practice rather than that of the ship's earlier years. Clearly illustrated are the main braces leading aft to bunks on the quarters. When fully fitted the fore braces will lead to blocks near the top of the main stay. The latter practice was typical of military vessels where it was necessary to keep rigging clear of the guns. The fore braces of merchant vessels often lead to sheaves in the waist.



THE RUNNING RIGGING OF A MAIN OR FORE COURSE

- 1 Topmast
- 2 Cap
- 3 Top
- 4 Bunt block
- 5 Bunt Lines
- 6 Bunt line monkey blocks
- 7 Leech line monkey block
- 8 Leech line
- 9 Lift
- 10 Reefing tackle
- 11 Footrope
- 12 Stirrup
- 13 Brace Pendant
- 14 Brace
- 15 Clew Garnet
- 16 Clew Garnet Block
- 17 Quarter Block for Topsail Sheet
- 18 Topsail Sheet Block (Sheet line not shown)
- 19 Lift Block
- 20 Robbands (Rope bands)
- 21 Reef points
- 22 Jeers
- 23 Jeer Tyes
- 24 Slings
- 25 Sling Cleat
- 26 Reef Band
- 27 Cringle
- 28 Clew of Sail
- 29 Clew Block
- 30 Tack Block
- 31 Sheet Block

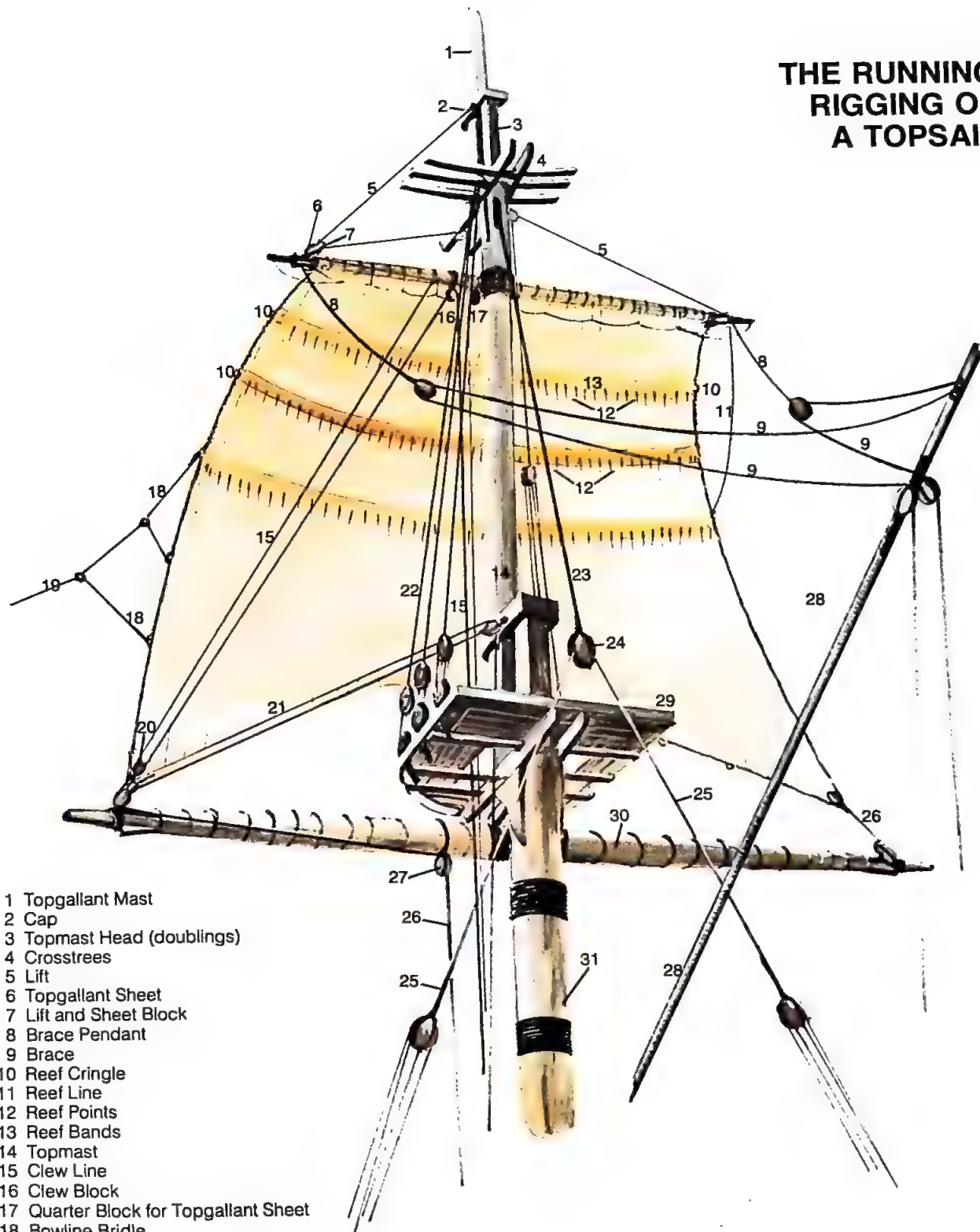


- 32 Sheet (not rigged if tack is rigged)
- 33 Tack (not rigged if sheet is rigged)
- 34 Bowline Bridle
- 35 Bowline
- 36 Buntline Cloths
- 37 Buntline Cringles
- 38 Fife rail
- 39 Main or Fore Mast
- 40 Belaying Pin



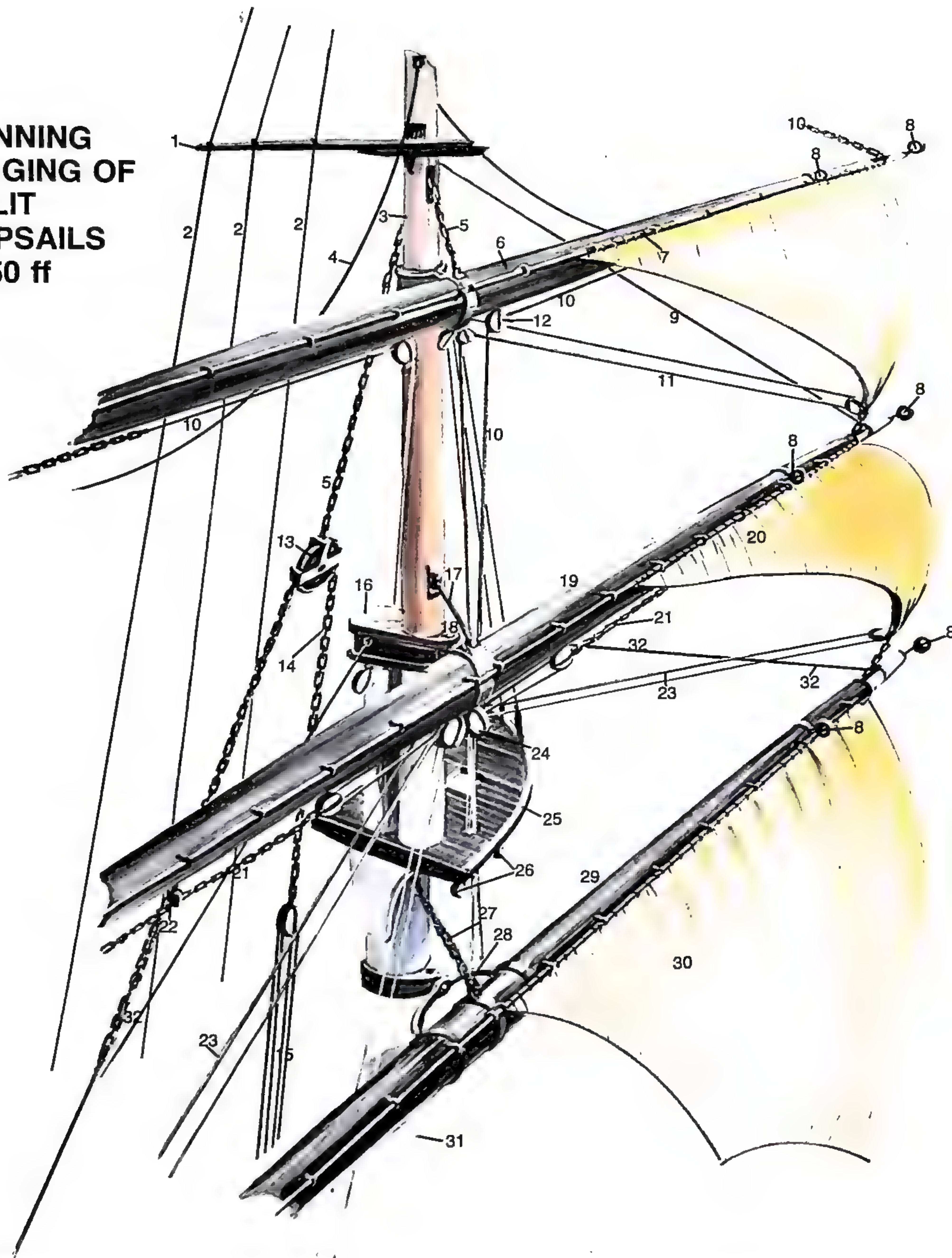
Don Dressel's pirate brig of about 1750 provides an example of a model fitted with sails. Don had the opportunity to rig tacks, bowlines, jib sheets and other lines which would normally be left off a model without sails. Note the great size of the topsails of this era.

THE RUNNING RIGGING OF A TOPSAIL



- 1 Topgallant Mast
- 2 Cap
- 3 Topmast Head (doublings)
- 4 Crosstrees
- 5 Lift
- 6 Topgallant Sheet
- 7 Lift and Sheet Block
- 8 Brace Pendant
- 9 Brace
- 10 Reef Cringle
- 11 Reef Line
- 12 Reef Points
- 13 Reef Bands
- 14 Topmast
- 15 Clew Line
- 16 Clew Block
- 17 Quarter Block for Topgallant Sheet
- 18 Bowline Bridle
- 19 Bowline
- 20 Clew Block
- 21 Lower Yard Lift
- 22 Topmast Shrouds
- 23 Topsail Tye
- 24 Topsail Tye Block
- 25 Topsail Halyards
- 26 Topsail Sheet
- 27 Quarter Block
- 28 Main or Mizzen Stay
- 29 Top
- 30 Lower Yard
- 31 Lower Mast

RUNNING RIGGING OF SPLIT TOPSAILS 1850 ff



- 1 Crosstrees
- 2 Backstay
- 3 Topmast
- 4 Upper Topsail Lift (single span, fixed)
- 5 Chain Tye
- 6 Upper Topsail Yard
- 7 Upper Topsail Bent to Jackstay
- 8 Stunsail Boom Irons
- 9 Lower Topsail Lift (single span, fixed)
- 10 Topgallant Sheet
- 11 Upper Topsail Clew Line
- 12 Quarter Block
- 13 Upper Topsail Tye Gin Block

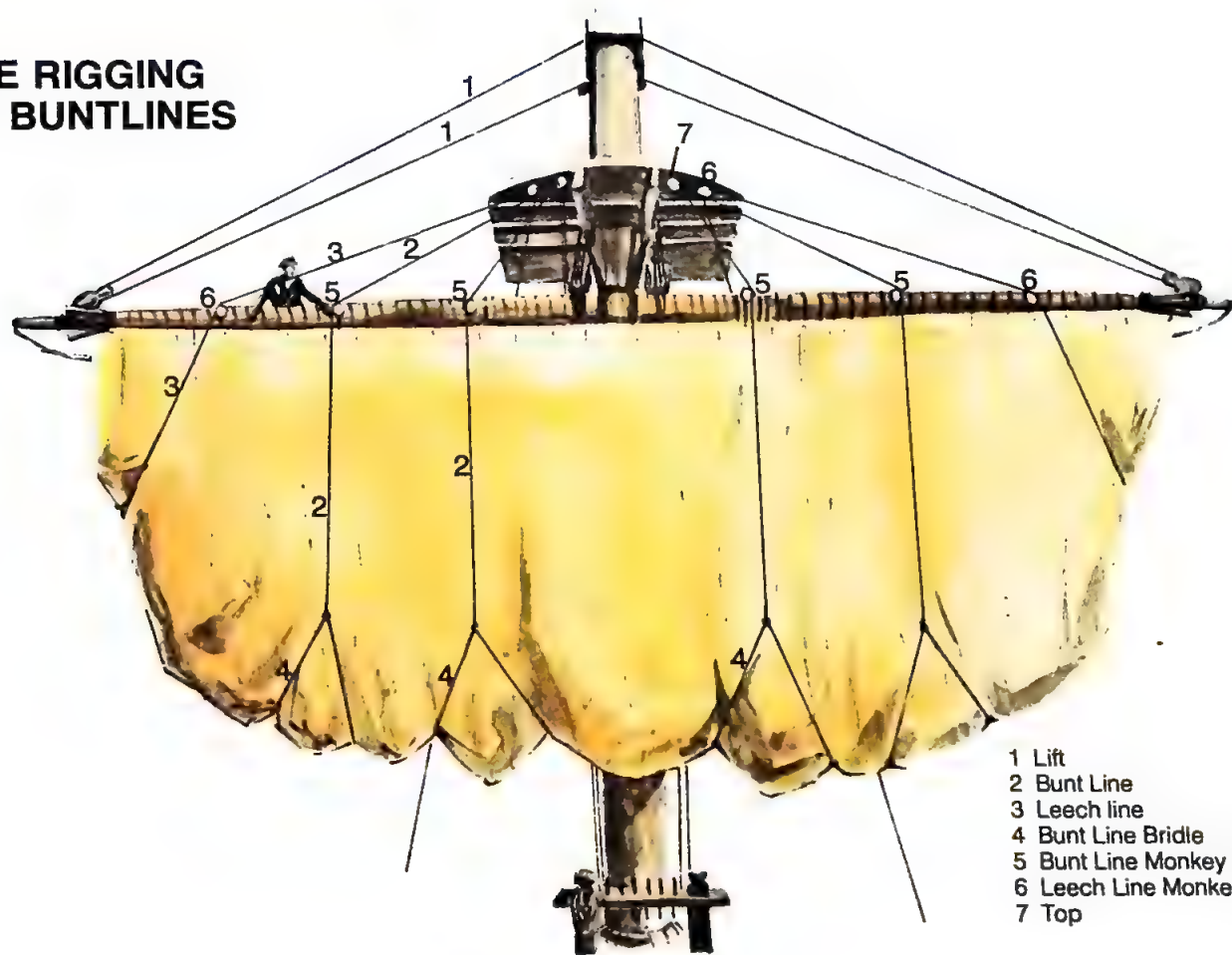
- 14 Chain Span
- 15 Upper Topsail Halyard Fall
- 16 Lower Mast Cap
- 17 Lower Topsail Tye Iron
- 18 Lower Topsail Crane
- 19 Lower Topsail Yard
- 20 Lower Topsail Bent to Jackstay

- 21 Upper Topsail Sheet
- 22 Fair Lead for Sheet
- 23 Lower Topsail Clew Lines
- 24 Quarter Blocks (sometimes a pair of bullock blocks)
- 25 Top
- 26 Bunt Line Blocks
- 27 Lower Yard Sling
- 28 Iron Swivel Truss
- 29 Lower Yard
- 30 Course Bent to Jackstay
- 31 Lower Mast
- 32 Lower Yard Lift (single span fixed)



The *Cutty Sark*, built in 1869, is a prime example of a ship fitted with split top-sails. In this view, the upper topsail yard is shown in the lowered position. Lifts, clew lines and the 'V'-shaped crossrees typify the era of the clippers. Note the footropes and Flemish horses on the yards.

THE RIGGING OF BUNTLINES



- 1 Lift
- 2 Bunt Line
- 3 Leech line
- 4 Bunt Line Bridle
- 5 Bunt Line Monkey Block
- 6 Leech Line Monkey Block
- 7 Top

A reconstruction of Sir Francis Drake's "*Golden Hind*" in San Francisco provides a clear example of late 16th century rigging. Rigging of this sort stayed in use through a good part of the 17th century as well. At right the main and topsail lifts, the somewhat outboard quarter blocks, the lead of the topsail braces to the mainstay, and a particularly heavy cap are in evidence. The heavy line to the left is the forestay.

The yardarms of the *Golden Hind* display the unique 17th century block arrangement for the lifts and sheets. The upper block is for the lift while the larger, lower one is for the topsail sheet. The sheet reeves through this block and back along to the quarter blocks on the underside of the yard near the mast, then down to the deck.

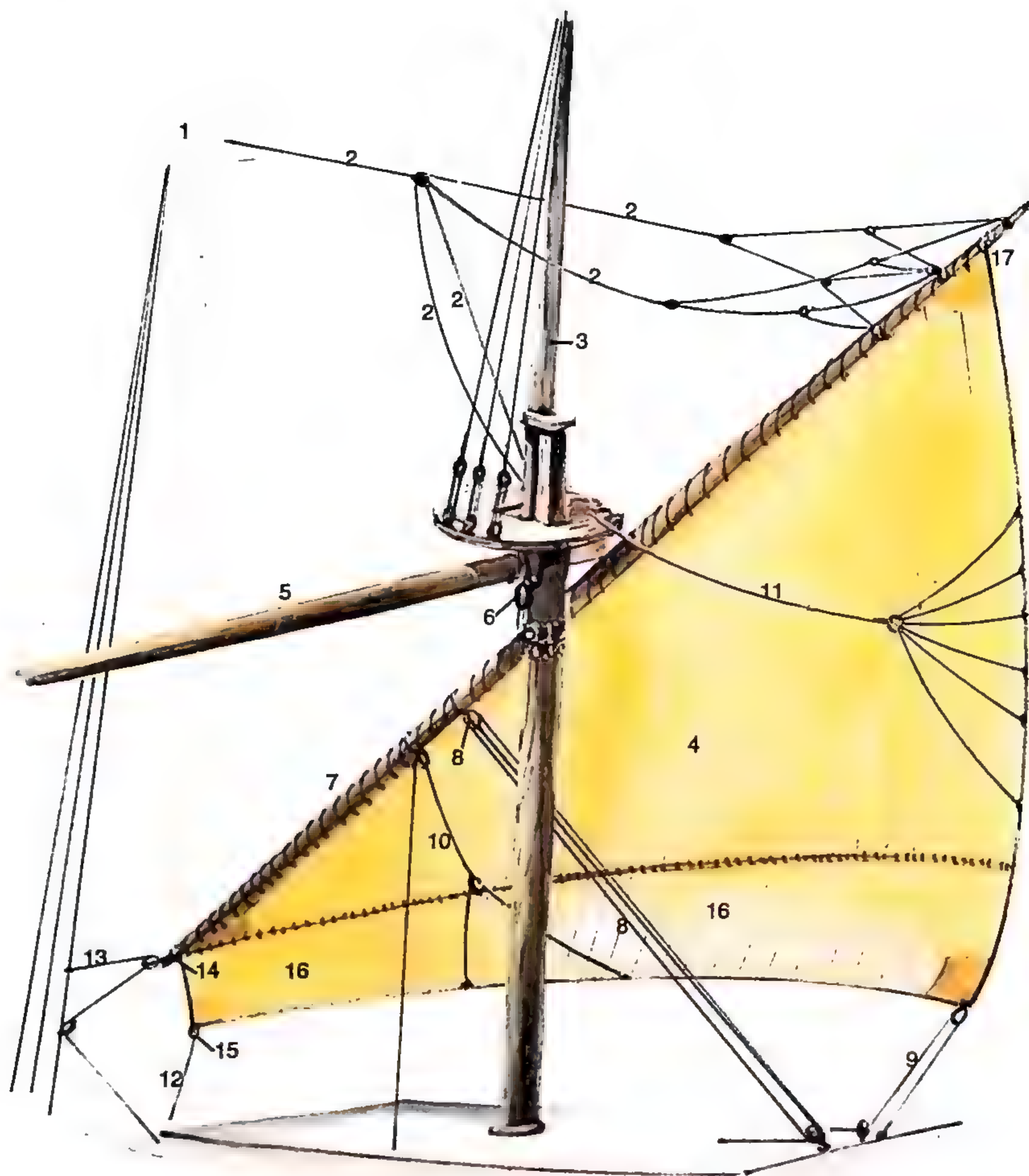




Craftsmen and sailors of the 18th and 19th centuries built exquisite models of bone and ivory such as this one. The model exhibits the lofty masts and extended bowsprit typical of the ships of about 1800.

Left: The maker of this model brig rigged bowlines and sheets even without sails. The lines are tied off on the yards at the points where they would lead if attached to furled sails.

THE RUNNING RIGGING OF A LATEEN MIZZEN SAIL - 1700



- 1 Main Top
- 2 Mizzen Lift
- 3 Mizzen Topmast
- 4 Mizzen
- 5 Crossjack
- 6 Jeers
- 7 Mizzen Yard
- 8 Sheet when sail is furled
- 9 Sheet when sail is set
- 10 Martnet and Brail
- 11 Martnet (both sides of sail)
- 12 Tack Line
- 13 Bowline
- 14 Nock of sail
- 15 Tack of sail
- 16 Bonnet
- 17 Peak

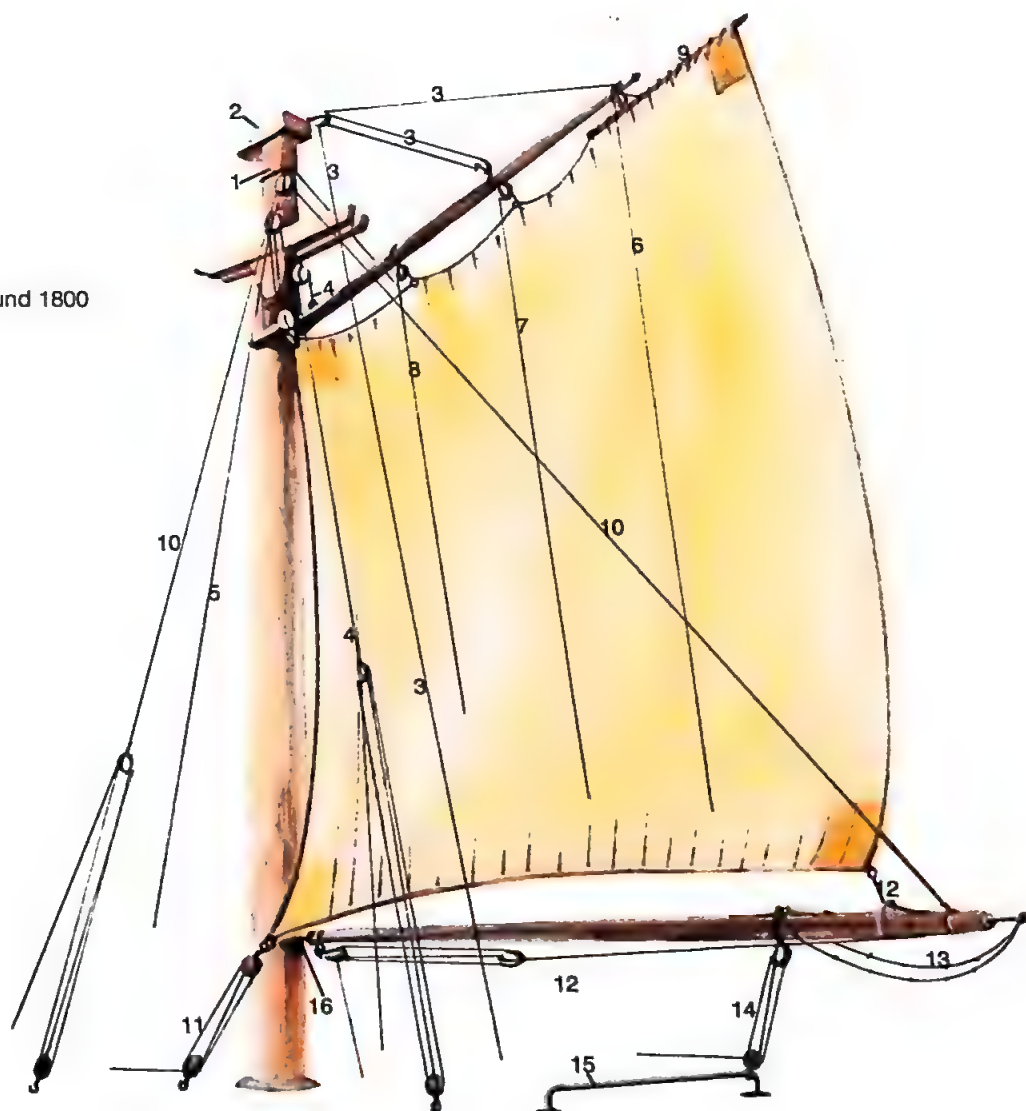


Left: View of the after side of the *Constellation's* mizzen mast shows the spanker boom jaws fitted to the trysail mast (a second thinner mast abaft the hoops). Such a mast was also called a spencer mast or snow mast. Note the iron band wooldings.

THE RUNNING RIGGING OF A SPANKER - 1800

One of several rig variations in use around 1800

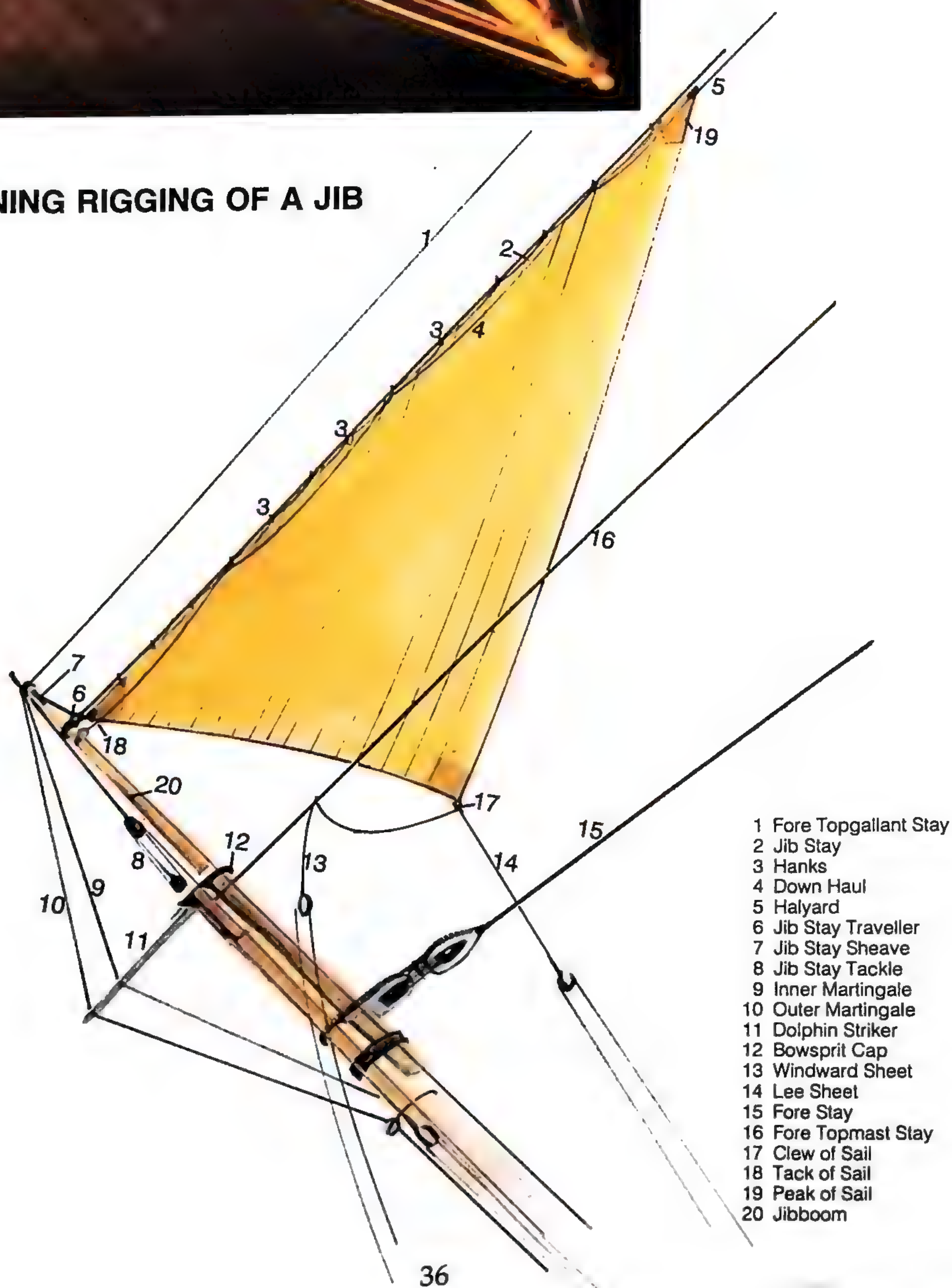
- 1 Mizzen Mast
- 2 Cap
- 3 Peak Tye
- 4 Throat Tye
- 5 Throat or Nock Halyard
- 6 Outer Halyard
- 7 Middle Halyard
- 8 Inner Halyard
- 9 Spanker Yard
- 10 Topping Lift
- 11 Tack
- 12 Sheet Rope
- 13 Horse or Foot Rope
- 14 Sheet
- 15 Traveller
- 16 Gooseneck



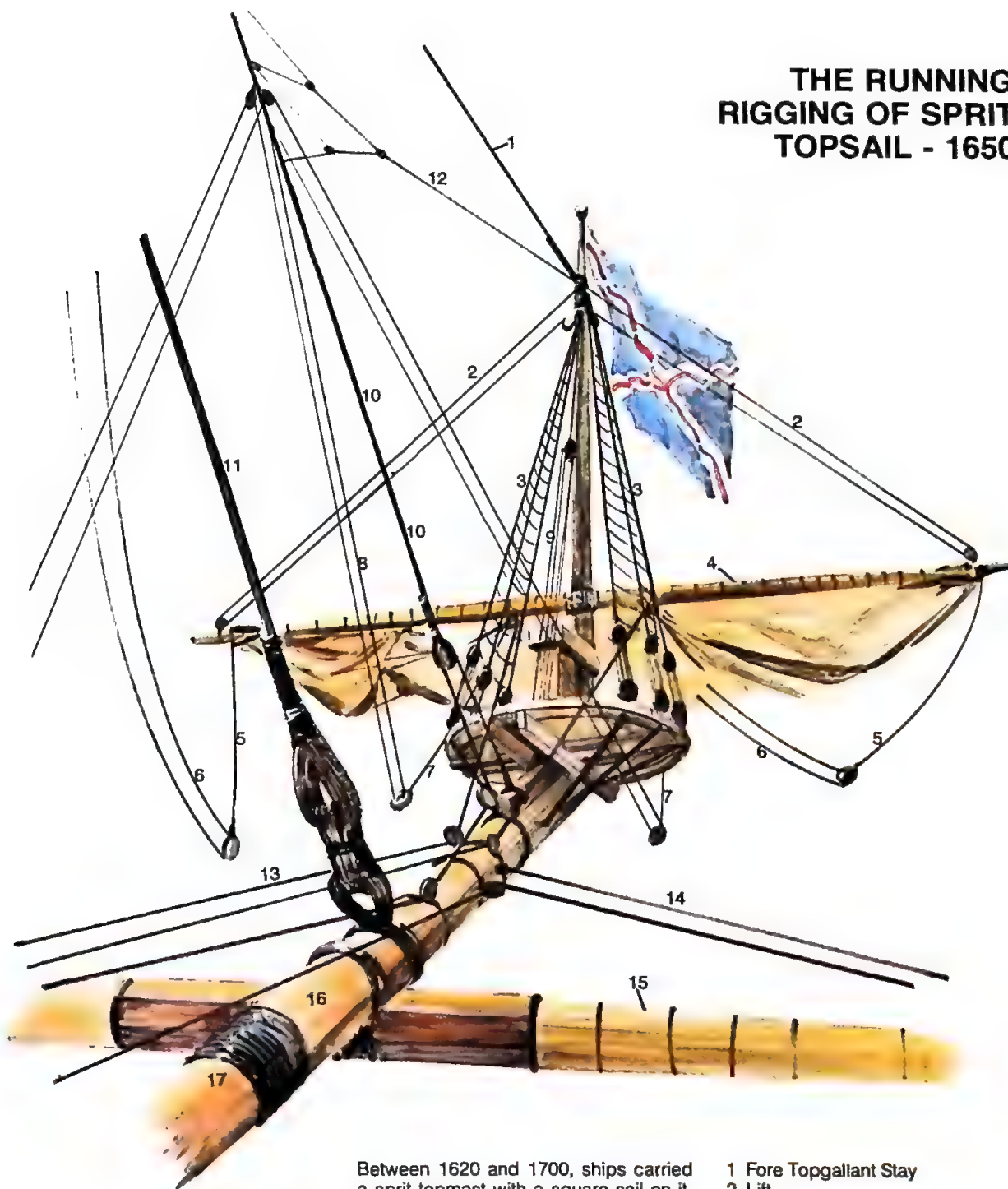


The bow of the "Irene" illustrates the typical rigging of a square spritsail which remained a standard part of a ship's rig through the 1820's. By 1800, however, the sail was seldom used being replaced by more practical jibs. The spritsail yard changed in function to that of a spreader for the jibboom backropes. The sprit yard was rigged essentially like the others with lifts, braces, clews, sheets and halliards.

RUNNING RIGGING OF A JIB



THE RUNNING RIGGING OF SPRIT TOPSAIL - 1650



Between 1620 and 1700, ships carried a sprit topmast with a square sail on it. Securing the mast upright on the end of the bowsprit led to an awkward and complicated system of shrouds and stays set up with blocks and crow's feet to the fore or fore topmast stays. Braces, lifts, clews and the like led from the sail and spar aft and upward through leading blocks on the forestays then to the forecandle deck. The plan was to keep the lines clear of the bow gun line of fire.

- 1 Fore Topgallant Stay
- 2 Lift
- 3 Shrouds
- 4 Sprit Topsail Yard
- 5 Brace Pendant
- 6 Brace
- 7 Sheet Pendant
- 8 Sheet
- 9 Halyard
- 10 Fore Topmast Stay
- 11 Forestay
- 12 Spritsail Topmast Backstay
- 13 Clew Line
- 14 Spritsail Lift
- 15 Spritsail Yard
- 16 Bowsprit
- 17 Woolding



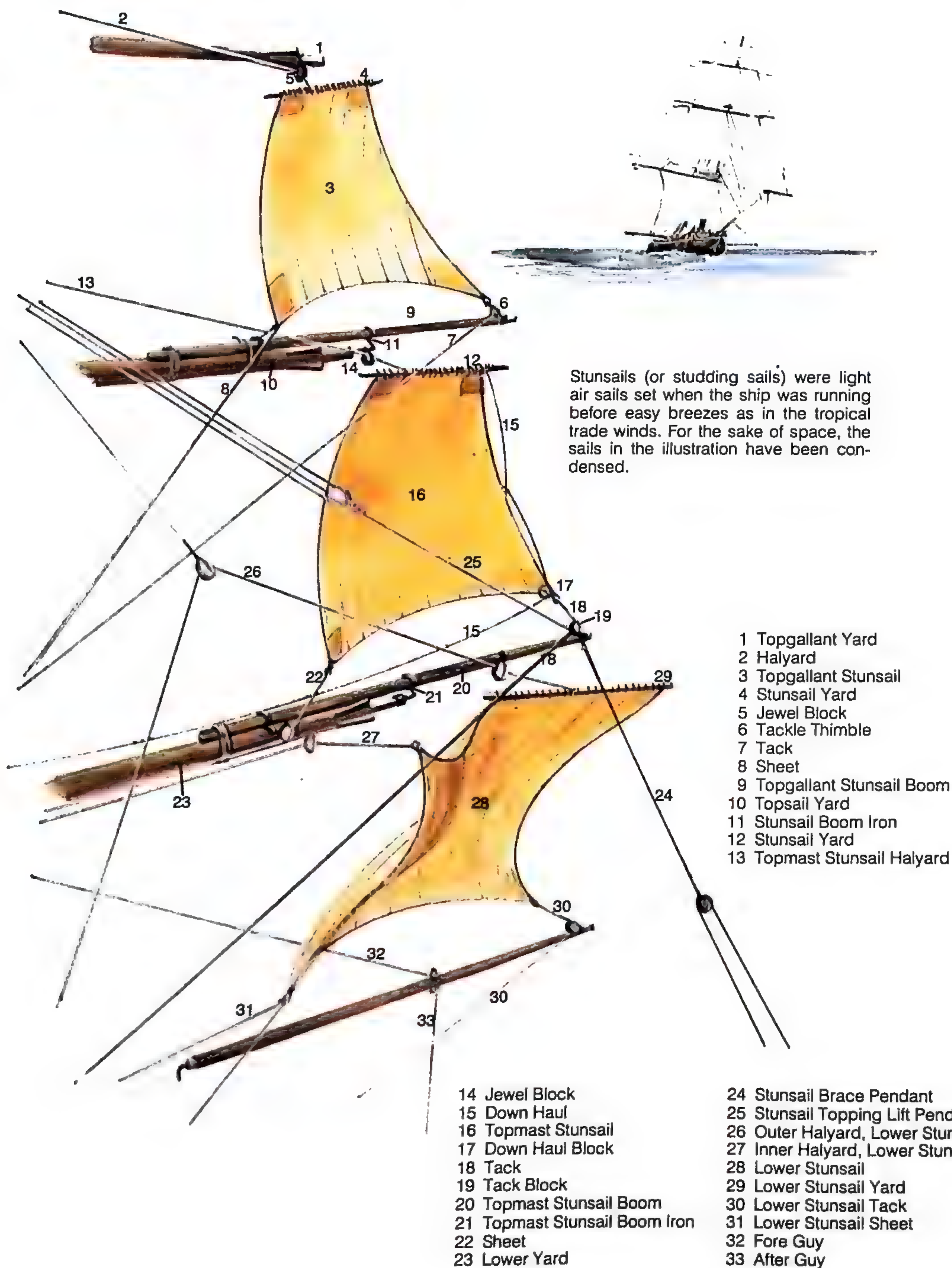
This model of a Gloucester fishing schooner exhibits a fore staysail with a bonnet (a removable extension of the sail's foot). The windward sheet of the jib can be seen draped over the fore-stay.

**RUNNING
RIGGING
OF
TOPGALLANT
AND HIGHER
SQUARE SAILS**

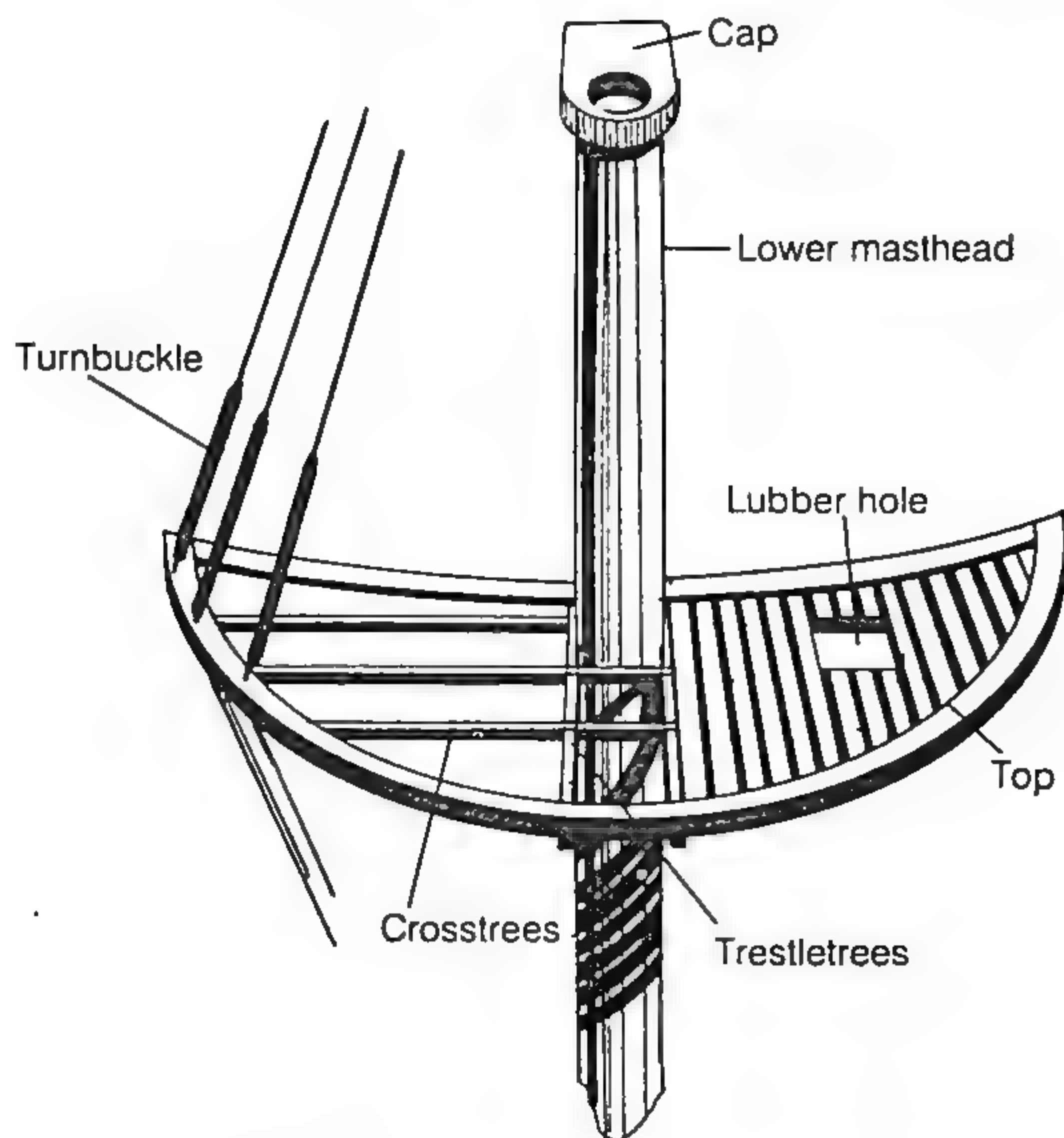


The running rigging of the higher square sails (topgallants, royals and skysails) was similar in principle to that of the lower ones but lighter. As may be seen here, the "Irene's" topgallant lifts go single while those of the topsail and lower yard go double. Cordage, block sizes and other elements were similarly lighter.

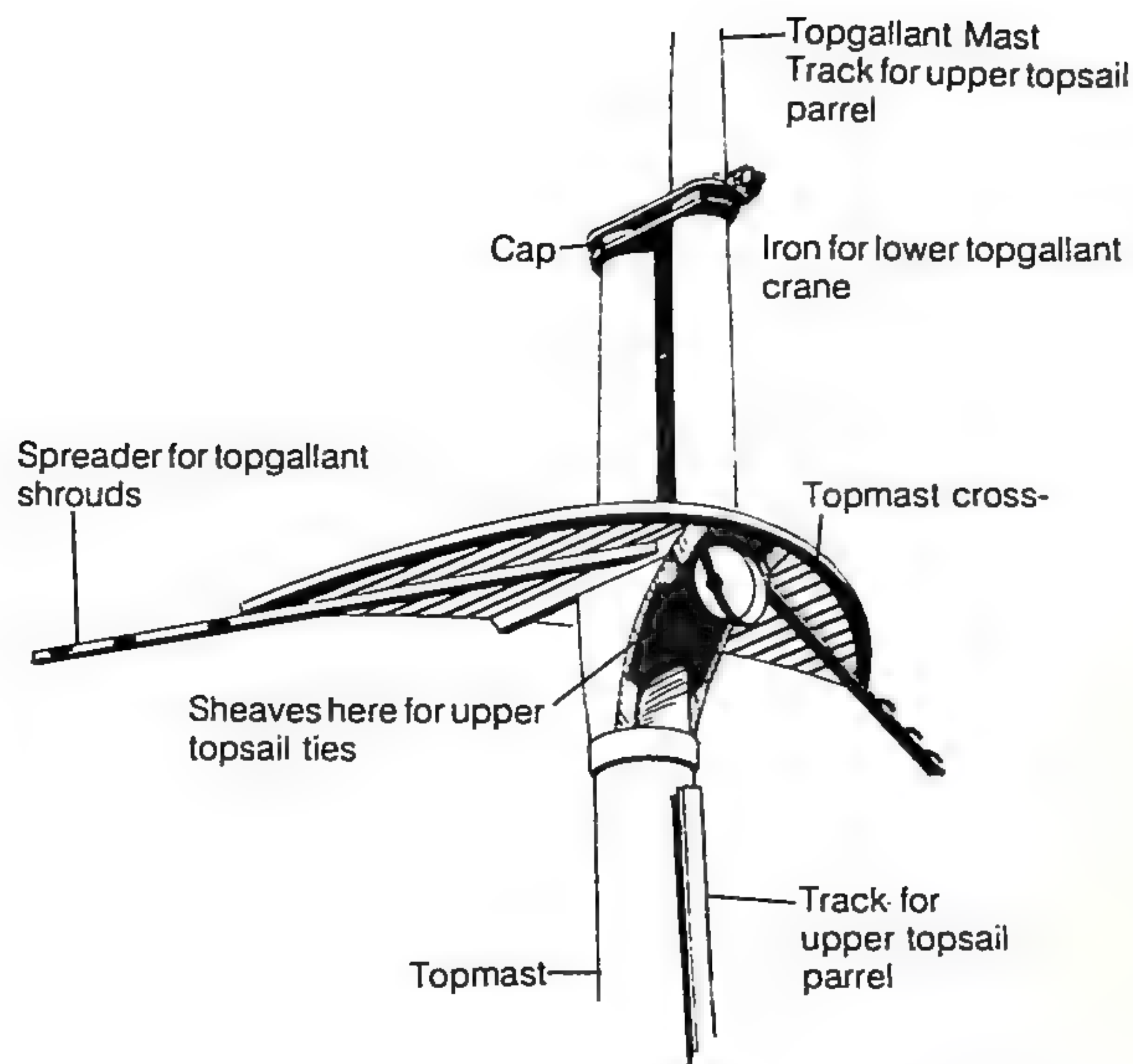
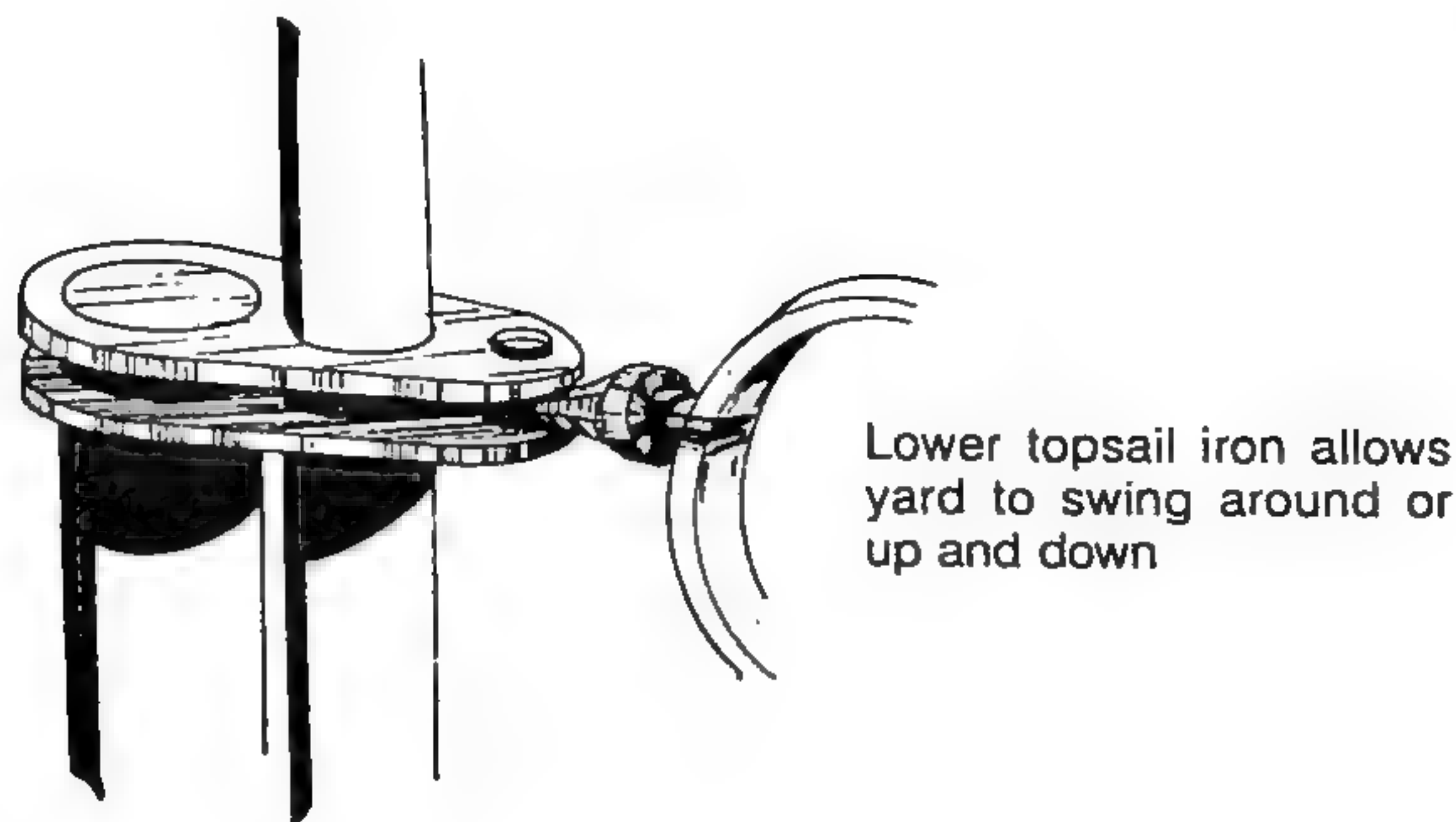
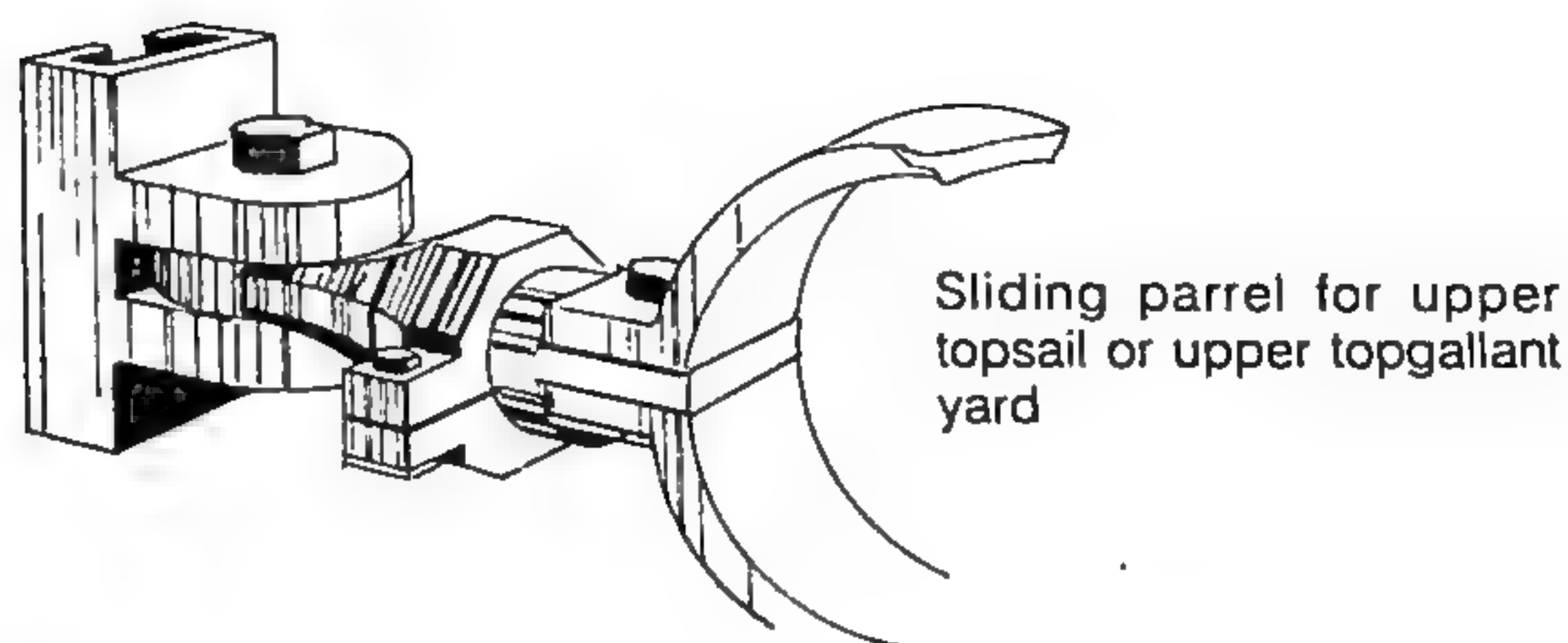
THE RUNNING RIGGING OF STUNSAILS



19TH CENTURY DETAILS



After 1850 crescent shaped tops characterized clipper ships and iron sparred windjammers. Note the outboard lubber holes.

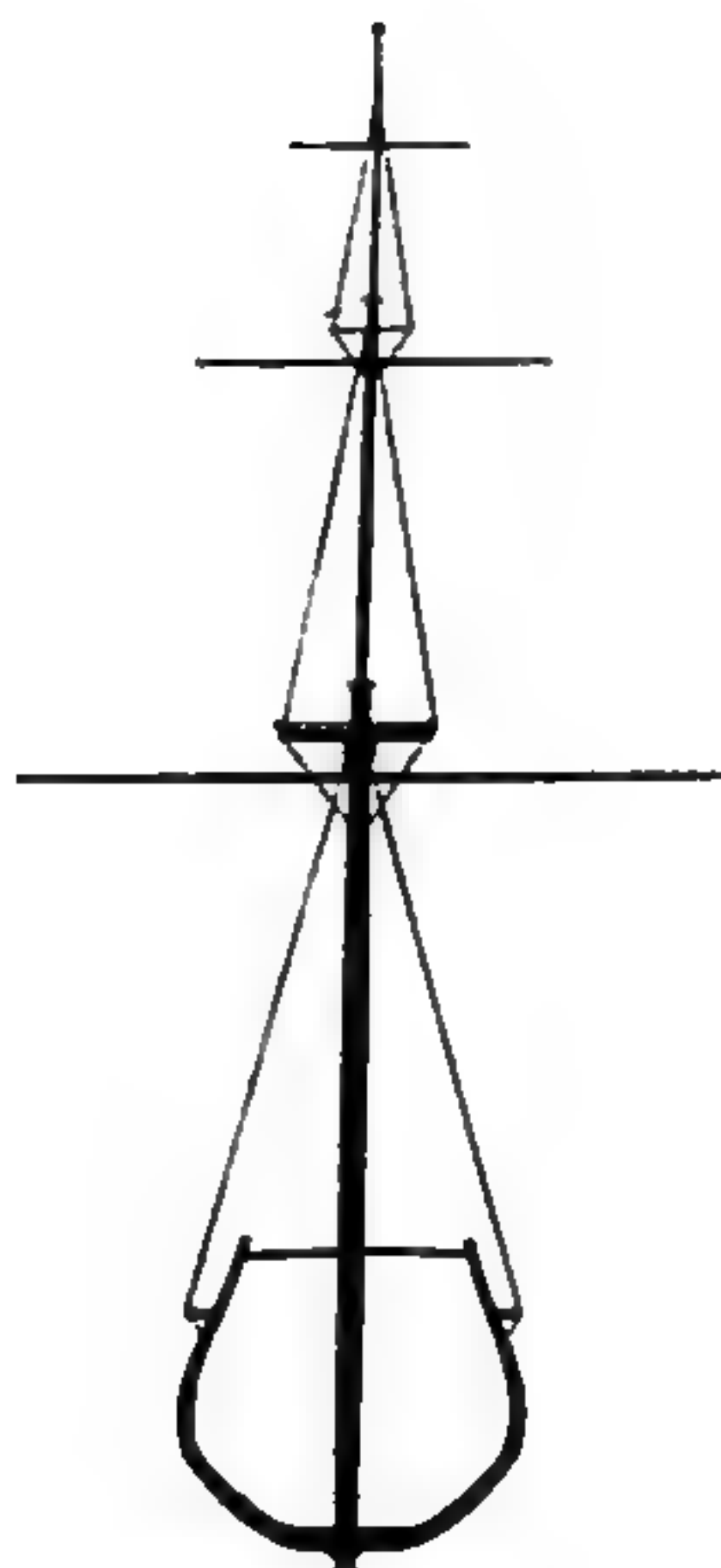


Topmast crosstrees sometimes were fitted with a "top" or working platform.

During the final half-century of the age of commercial sail, iron and steel played a larger and larger role in ship's rigging. In many cases, the masts themselves were metal, while blocks, eyebolts, trestletrees, tops and the like were welded or bolted to them.

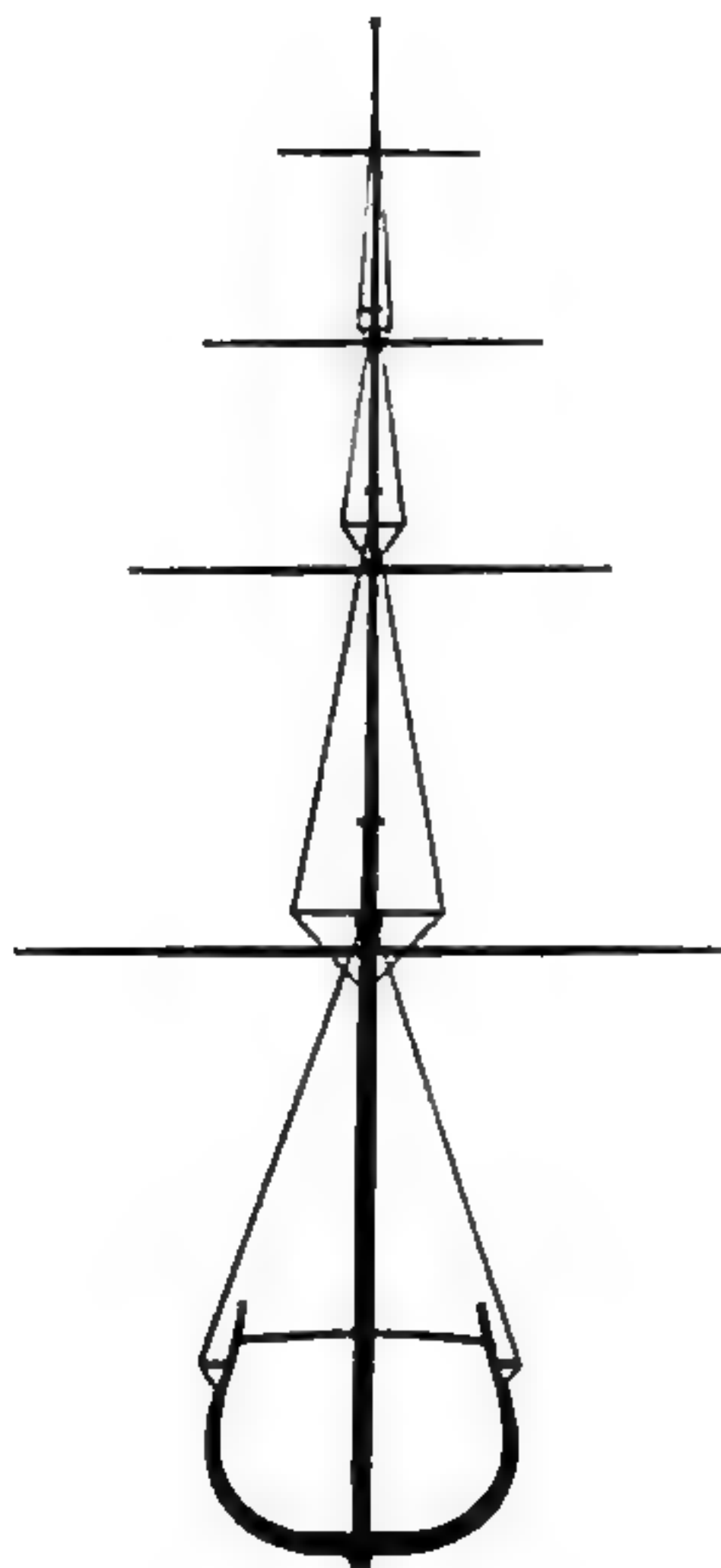
Lower topsail and lower topgallant yards were often permanently fixed to the caps with iron cranes. Chain ties and iron trusses similar to universal joints fixed lower yards, while upper sails were raised and lowered on tracks. Turn buckles and wire rope replaced deadeyes and hemp for shrouds. Chain sheets led through sheaves in the yard arms then inboard to bullock blocks (replacements for the old quarter blocks). The heavy upper topsails were hauled aloft with tie and halliard systems including a chain span rove through a "gin block."

YARDS



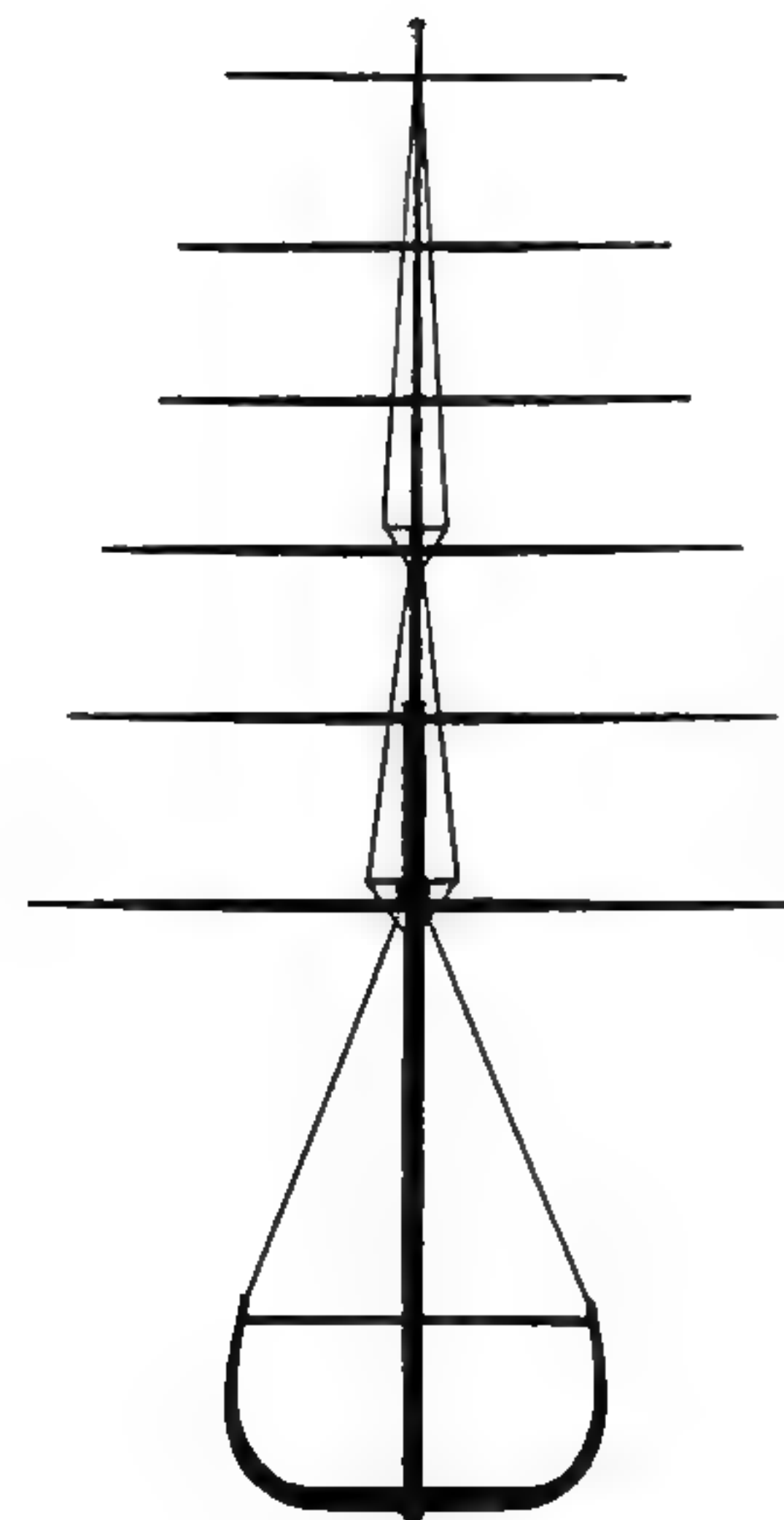
17TH CENTURY

Yards diminished rapidly in length from lower to higher. Lower main yard length: 2.4 times beam.



18TH CENTURY

Yard lengths increased. Lower main yard length: 2.28 times beam.



19TH CENTURY

Yard lengths tending to be more equal in length. Lower main yard length: 2.1 times beam.

Yards, like masts, are a major determinant of the number, shape and placement of sails on a vessel. The largest sails were the lower courses (the main and fore sails). The higher sails tapered upward, the yards becoming proportionately shorter the higher they were set. Through the centuries, the taper of the sails changed from quite radical in the 1600's to very gradual by 1850. The lengths of the upper yards, therefore, came more and more to approximate the length of the yard just below it.

About 1730 square spritsails gave way to fore and aft jibs. The innovation unbalanced the rigs. The first solution to the problem was to lengthen the yards. Thus for a period in the 18th century we find main yards up to 2.25 times the beam of the ship. Later about 1800, the main yard length was cut back to about twice the beam and the rig balanced by enormous jib-booms extending nearly half the ship's length before the bow.

The diameters of the yards, like masts, had prescribed values, but varied from ship to ship for the same reasons—inconsistency of material and method of manufacture.

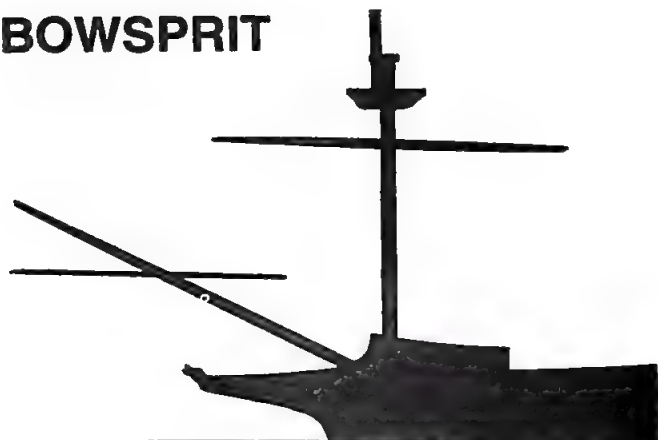
In general, the maximum diameter of a yard was about 2% of its length. This held true of all spars in the 17th century, though as the length of upper yards increased in the 18th and 19th centuries, their diameters diminished to about 1½% of their lengths.

Yards tapered like masts along the line of large arcs tangent at the center to a diameter at the yard arm (the outer end) of about 40% its diameter at the center.

Through the 18th century, the center third of a yard was octagonal in section. Sail robbands (rope bands) went around the entire spar while the head cringles were lashed to the yardarms around stop cleats with earrings.

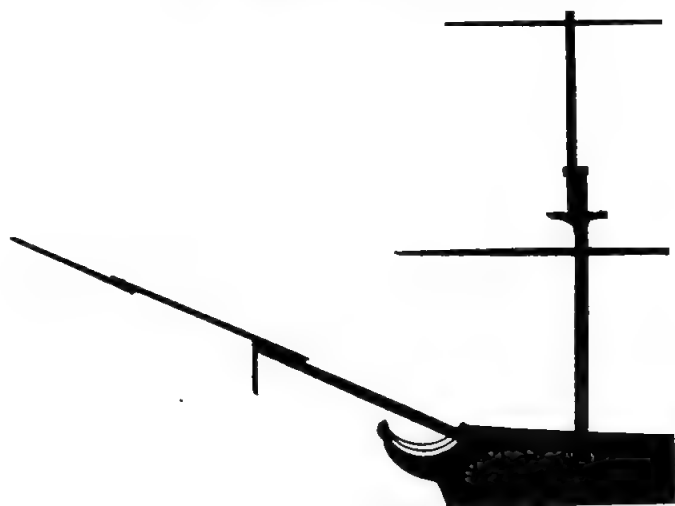
Shortly into the 19th century, yards were made round throughout their length and were fitted with jackstays to which the sails were bent. A jackstay consisted of a piece of line, (later a steel rod) rove through eye bolts set into the upper forward edge of the yard. The jackstay held the sail well up on the spar and made it easier to furl.

BOWSPRIT



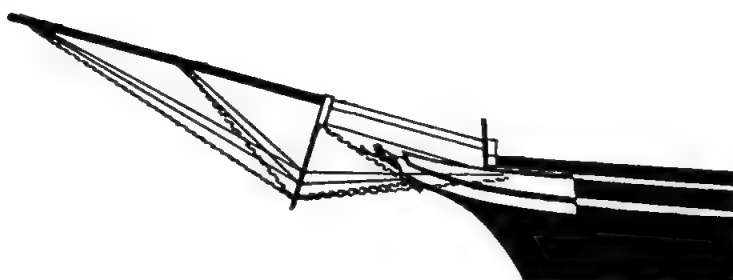
17TH CENTURY

STEEVE - 22 DEGREES
 LENGTH 88% of mainmast
 LENGTH 27% of mainmast
 About 25% of the bowsprit was inboard.



18TH CENTURY

STEEVE - 35 DEGREES
 LENGTH (45% of main mast)
 LENGTH JIBBOOM (41% of main mast)
 30% of the bowsprit was inboard while the jibboom overlapped the bowsprit about 25% of its length. Additional jib-booms might add to the overall length.



19TH CENTURY

STEEVE - 20 DEGREES
 LENGTH (37% of main mast)
 LENGTH JIBBOOM (63% of main mast)
 30% of the bowsprit was inboard. The jibboom overlapped the whole length of the bowsprit.

The bowsprit through the centuries changed in function, shape and manner of rigging more than any other spar.

Originally in the 12th century, the bowsprit was used exclusively as a means of holding the forward tack of the mainsail forward. Then around 1450 it occurred to someone to set a squaresail on it and the spritsail was born. A second sail, the spritsail topsail, appeared in the 17th century and these two sails stayed in use until about 1710 when the spritsail topsail was replaced by fore and aft jibs. Finally the square spritsail itself was retired about 1800.

The steeve (the angle between the sprit and the deck) progressed from about 22 degrees in 1650 to 35 degrees in 1750 and back again to about 20 degrees in 1825.

The spritsail topmast was a curious development of the 17th century that came with the sail of the same name. It grew out of the need to get more sail area forward as mentioned above, but securing a little, short mast on the end of another spar led to difficulties. The spritsail topmast was a frequent casualty in heavy weather.

Jib-booms, fixed parallel with the bowsprit itself, proved more practical. Originally, the jib-boom was rigged off to the side of the sprit so as not to interfere with the stays. Later it followed the centerline of the sprit, and the stays were led to the side through bee blocks.

Around 1800 jib-booms sprouted flying jib-booms, and flying jib-booms, jib-of-jib-booms. The flying jib-boom mounted on the upper port side of the jib-boom; the jib-of-jib-boom on the upper starboard side of the flying jib-boom.

The first bowsprits up to about 1600 sailed "on-the wood." They had no rigging but the bow timbers and steps inboard to hold them in place. A little later in the century a "gammoning" appeared. The gammoning lashed the sprit down to the beakhead and helped offset the powerful up and after haul of the forestays.

Around 1700 the bobstay came into use to further assist the cause and finally toward the end of the 18th century, martingales played bobstay to the way outboard jib-booms.

DIMENSIONS OF SPARS

To Use This Chart:

- 1 Measure the beam of the model at the widest point. For example: Beam equals 6"
- 2 Determine era of vessel and use only the columns so marked. ex. 1650
- 3 Determine height of mainmast - multiply the number under the era opposite entry "A. LOWER" in the **MAINMAST** column by the beam. ex. $2.4 \times 6"$ equals 14.4"
- 4 To find the height of any other mast or yard multiply 14.4" times the decimal fraction in the appropriate box.
ex. the fore topmast entry under 1650 is .42
.42 times 14.4" equals 6.048". Hence the fore topmast of your model will be 6.048" long.
ex. the length of your lower mizzen (cross jack) yard would be $.50 \times 14.4"$ equals 7.2".

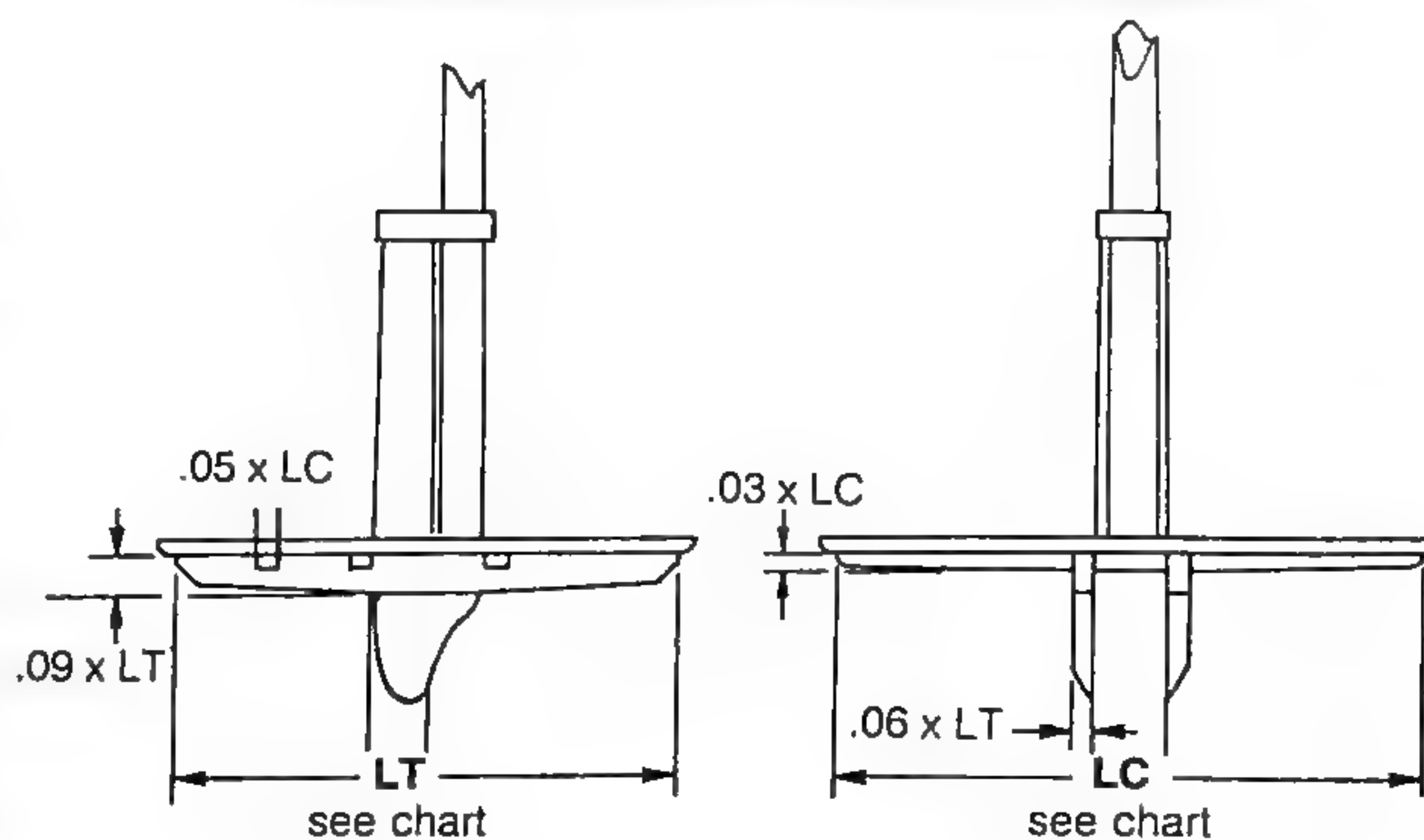
Remember that the dimensions given are but mean averages for the general run of ships in these periods. The mast dimensions of a particular vessel could vary from those shown depending on type, nationality, or dozens of other factors. If, however, your plans call for dimensions radically different from these, do some independent research. The chances are your plans are in error.

LOWER MAIN MAST—Length expressed as a multiple of the ship's beam. Other mast lengths expressed as fractions of main mast lengths.

LOWER MAIN COURSE YARD—Length expressed as a multiple of the ship's beam. Other yard lengths as fractions of main course lengths.

LENGTHS OF DOUBLINGS—expressed as fraction of associated mast.

PROPORTIONS OF TRESTLETREES



SIDE VIEW

TRESTLETREES

FRONT VIEW

CROSSTREES

MASTS as fractions of lower main mast	MAIN MAST			FORE MAST			MIZZEN MAST		
	1650	1750	1850	1650	1750	1850	1650	1750	1850
A LOWER	2.4 x Beam	2.28 x Beam	2.1 x Beam	.80	.90	.96	.75	.84	.86
B LOWER DOUBLINGS	.06	.13	.23	.05	.13	.18	.08	.095	.17
C TOPMAST	.52	.58	.77	.42	.57	.77	.34	.43	.60
D TOPMAST DOUBLINGS	.05	.06	.27	.05	.06	.15	.08	.095	.19
E TOPGALLANT MAST	.26	.31	*.91*	.21	.29	.86*	—	.22	.66

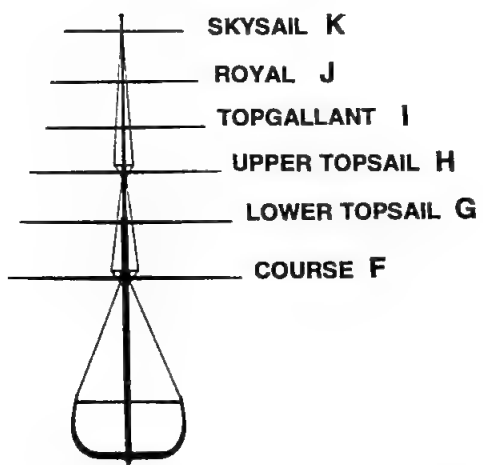
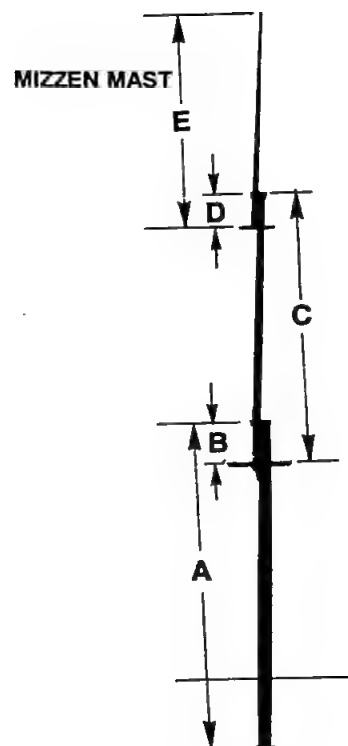
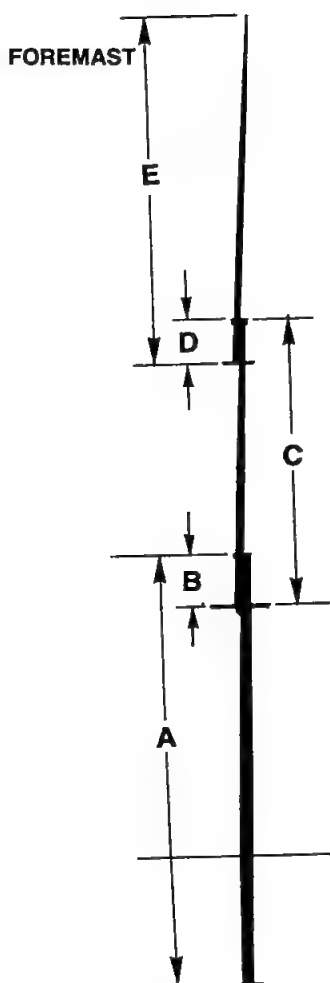
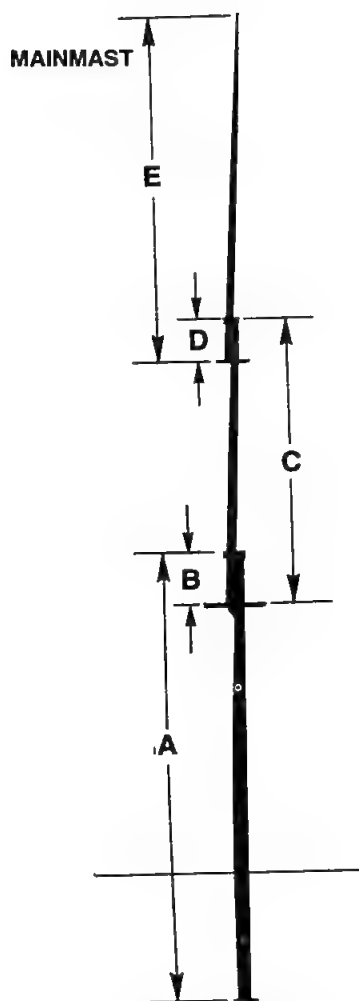
*Topgallant, Royal and Skysail on a single pole

YARDS as fractions of lower main yard	MAIN YARDS			FORE YARDS			MIZZEN YARDS		
	1650	1750	1850	1650	1750	1850	1650	1750	1850
F COURSE	2 x Beam	2.25 x Beam	1.9 x Beam	.85	.88	.88	.50	.60	.61
G TOPSAIL	.50	.70	.91	.43	.62	.80	.25	.30	.56
H UPPER TOPSAIL	—	—	.83	—	—	.73	—	—	.51
I TOPGALLANT	.25	.47	.66	.22	.41	.58	—	.24	.40
J ROYAL	—	—	.63	—	—	.55	—	—	.38
K SKYSAIL	—	—	.50	—	—	.44	—	—	—

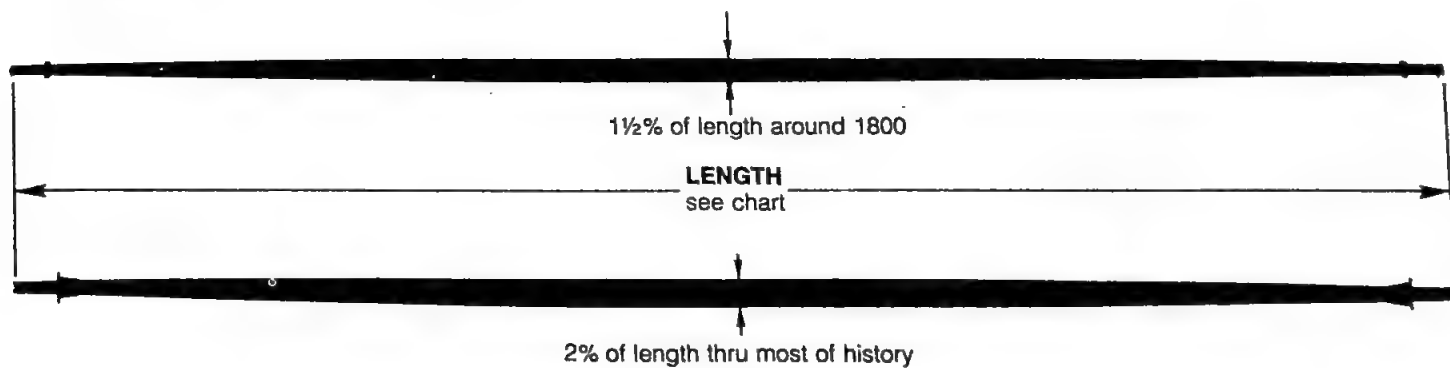
as fractions of main lowermast length	1650	1750	1850	1650	1750	1850	1650	1750	1850
LT TRESTLETREES (length)	.13	.145	.08	.10	.14	.075	.085	.108	.06
LC CROSSTREES (length)	.17	.19	.10	.11	.19	.095	.10	.14	.086

BOWSPRIT	.88	.45	.37
Length inboard (% of sprit)	.25%	.30%	.30%
SPRITSAIL TOPMAST	.27	—	—
JIBBOOM	—	.41*	.63

*Exclusive of additional outer spars



PROPORTIONS OF YARDS



FORE AND AFT RIGS

Up to now our focus has been on the great square rigged sailing ships. Booms, gaffs, and sprits bring our discussion around to a large class of vessels, the fore and aft riggers.

The earliest fore and aft riggers, as we have said, were the lateen sailed ships of the Mediterranean which became popular around 700 A.D. After them there were no developments until about 1400 when the Dutch popularized the sprit rig.

The sprit developed out of the need to navigate small ships and boats on inland waterways and near to shore where frequent tacking and beating to windward had to be managed.

The rig consisted of a loose footed main attached to the mast along its forward (luff) edge. Then a pole (the sprit) was rigged diagonally from a "snotter" at the base of the mast upward to the peak of the sail aft. The arrangement was wonderfully simple and efficient.

The spritsail had a drawback in that the sprit itself was a long and cumbersome spar. The inconvenience led to the development of the gaff. The gaff did the same job as the sprit except that the entire head of the sail, not just the peak clew, was laced to the spar, and both sail and spar were hoisted up the mast. The gaff pivoted on the mast in a pair of jaws.

Loose footed gaff sails never lost their place, but in a large number of cases a boom was added to the foot so that the sail could be stretched on spars along three of its four sides. The gaff stretched the head; the boom, the foot and the mast, the luff. Thus evolved the traditional "gaff-headed" rigs which were universal in fishing fleets, among coastal vessels, yachts, and dozens of other classes of ships, large and small.

Square riggers also required fore and aft sails to help them sail by the wind, maneuver and hold a steady course. This, from the beginning, was the primary role of the mizzen.

The mizzen mast appeared on northern European ships in the 1400's at which time it was rigged with a spritsail like the Dutch sprit rig described above. By 1500 however, a lateen mizzen came to be preferred and remained the standard until the latter years of the 18th century. At this time the lateen mizzen "steering sail" was superseded by a gaff headed spanker.

Other fore and aft sails also came into use on square riggers. Jibs and headsails, of course, were mostly fore and aft by 1750. Staysails gradually filled up every available stay between the fore and main masts and between the main and mizzen. Loose footed Spencer gaff sails echoed the mizzen spanker on the fore and main masts.

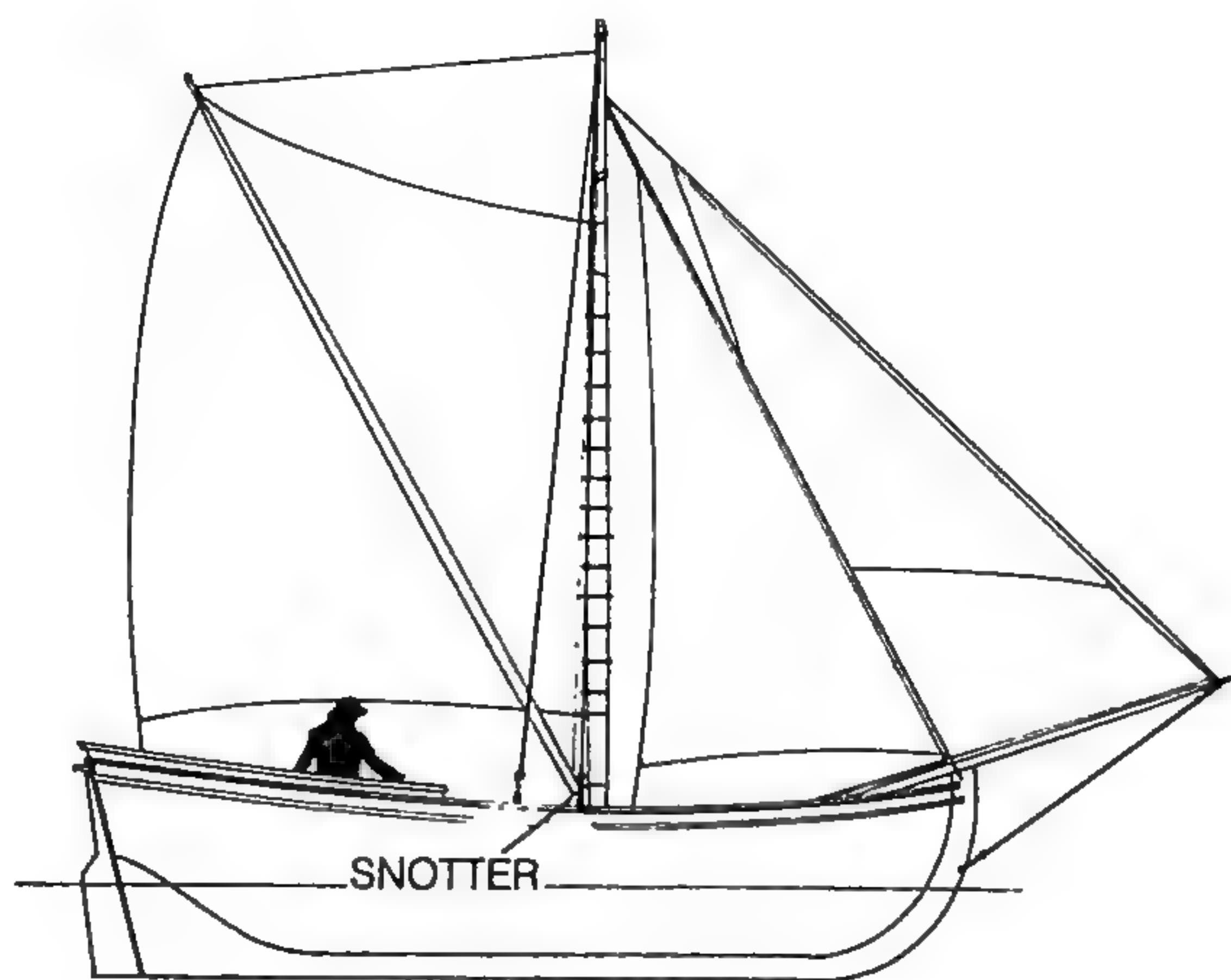
The lug rig developed as a variation of the fore and aft theme along in the 17th century. The rig

was used exclusively on small craft. The dipping lug consisted of a yard set similar to a lateen yard but with a sail shaped like a gaff sail. Coming about was a matter of slacking off the lug halyards and dipping the spar around the mast to the new lee side. The procedure was similar to that with a lateen rig.

The standing lug differed in that less of the lug was set forward of the mast and so approximated the operating characteristics of a gaff.

The Gunter rig was a standing lug where the lug was set almost straight up parallel with the mast.

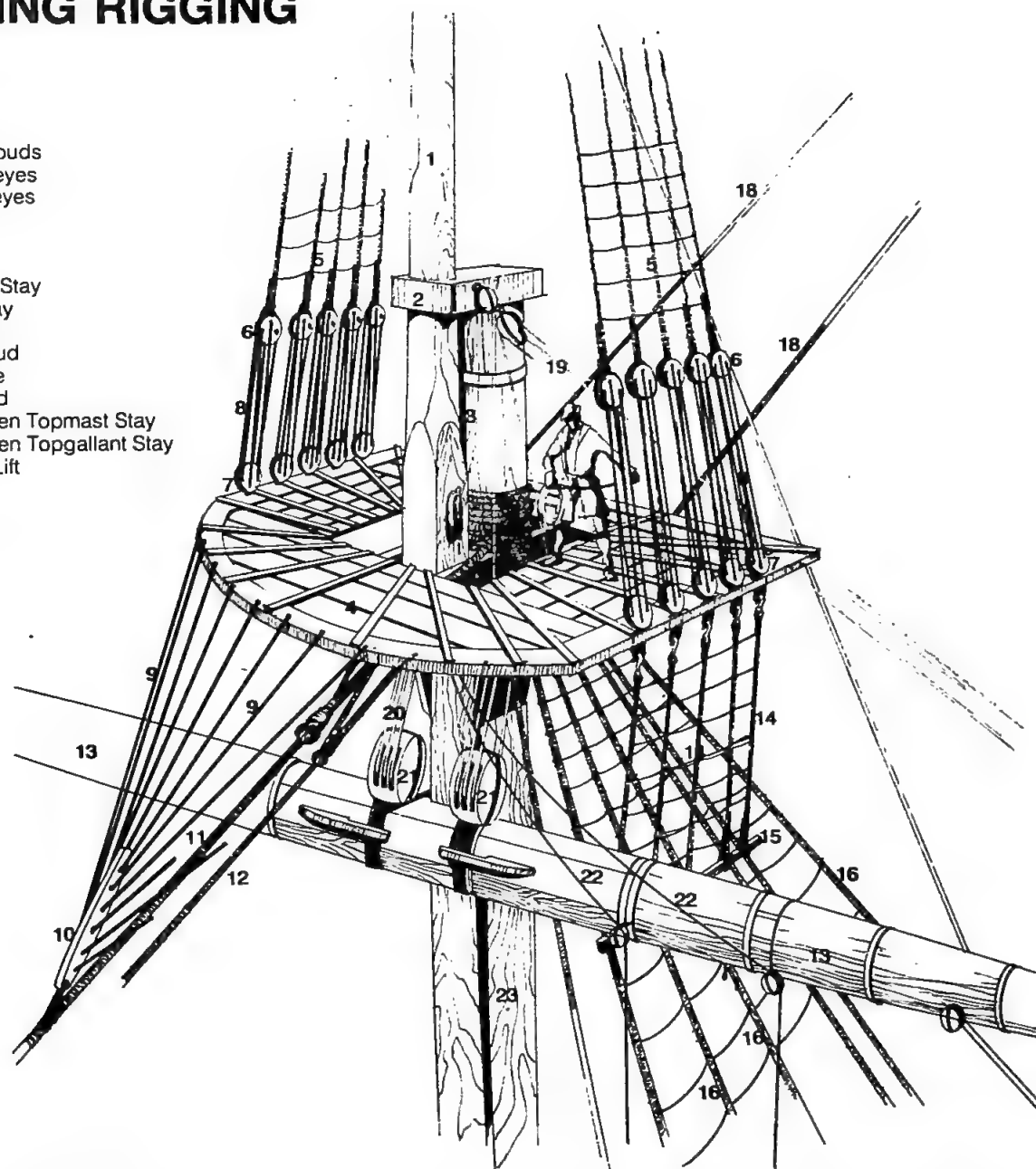
The last refinement of fore and aft rigs came with the development of the Marconi or Bermuda sails typical of modern yachts and sail boats. The rig consists of triangular sails set on high masts. It originated in Bermuda about 1800 and rapidly gained favor among West Indian island hoppers. Later, yachtsmen adopted the rig and since have brought it to a penultimate level of aerodynamic efficiency.



DUTCH SPRIT RIG

STANDING RIGGING

- 1 Topmast
- 2 Cap
- 3 Masthead
- 4 Top
- 5 Topmast Shrouds
- 6 Upper Deadeyes
- 7 Lower Deadeyes
- 8 Lanyards
- 9 Crow's Foot
- 10 Euphroe
- 11 Main or Fore Stay
- 12 Preventer Stay
- 13 Lower Yard
- 14 Futtock Shroud
- 15 Futtock Stave
- 16 Lower Shroud
- 17 Main or Mizzen Topmast Stay
- 18 Main or Mizzen Topgallant Stay
- 19 Lower Yard Lift
- 20 Jeers
- 21 Jeer Block
- 22 Bunt Lines
- 23 Lower Mast



The standing rigging of a ship consists of the lines whose primary function is the support or steadying of the masts and other spars. In general, the standing rigging is fixed and is not hauled on while the ship is underway nor is it ever taken down as a matter of routine.

Stays run from the top of masts to a lower point forward along the centerline of the ship. As a rule they are the heaviest lines aboard. Shrouds run from the top of masts aft and to the sides. They are the second heaviest lines aboard.

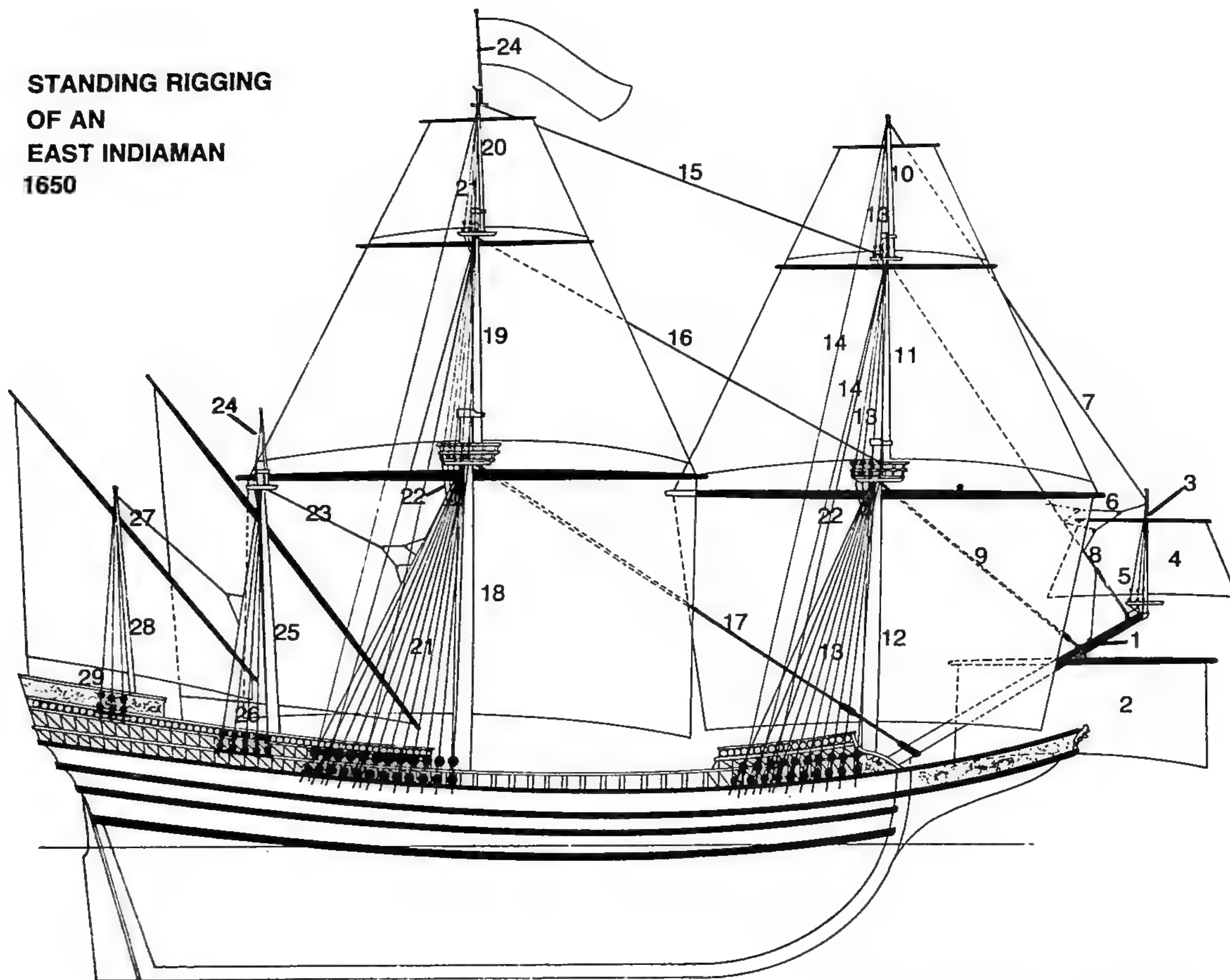
Backstays run similar to shrouds except that they usually apply to higher masts and run the whole distance from the upper mast heads to the deck. Upper mast shrouds end at the top of the next lower mast.

Mast and yard tackles, footropes, futtock shrouds, catharpins, yard slings and trusses, plus the martingales, backropes, and bobstay of the bowsprit, constitute the remaining elements of the standing rigging.

Until well into the 19th century all of these lines were made of rope or cable usually preserved with tar and variously treated as we have described earlier in this book. In the later years steel wire rope and chain replaced hemp for many parts of the standing rigging.

The characteristic of all cordage materials, however, was that they expanded and contracted to various degrees depending on moisture, temperature, age and natural elasticity. This fact brought about a continuous need to adjust tension on standing rigging.

**STANDING RIGGING
OF AN
EAST INDIAMAN
1650**



- 1 Bowsprit
- 2 Spritsail
- 3 Sprit Topmast
- 4 Sprit Topsail
- 5 Sprit Topmast Shrouds
- 6 Sprit Topmast Backstay
- 7 Fore Topgallant Stay
- 8 Fore Topmast Stay
- 9 Forestay
- 10 Fore Topgallant Sail and Mast

- 11 Fore Topsail and Fore Topmast
- 12 Fore Course and Foremast
- 13 Fore Shrouds (named for their masts)
- 14 Backstays (named for their masts)
- 15 Main Topgallant Stay
- 16 Main Topmast Stay
- 17 Main Stay
- 18 Main Course and Mainmast
- 19 Main Topsail and Topmast
- 20 Main Topgallant Sail and Mast

- 21 Main Shrouds (named for their masts)
- 22 Futtock shrouds
- 23 Mizzen Stay
- 24 Flagstaffs (named for their masts)
- 25 Lateen Mizzen Sail and Mast
- 26 Mizzen Shrouds
- 27 Bonaventure Mizzen Stay
- 28 Bonaventure Mizzen Sail and Mast
- 29 Bonaventure Mizzen Shrouds

The answer to this problem was found in the use of deadeyes and hearts. Deadeyes or hearts were arranged in pairs where one was seized to the rigging line and the other to the point to which it was to be fixed. Lanyards rove back and forth between them connecting the two.

As a rule shrouds were set up with deadeyes; stays with hearts. To set up a shroud, purchase was applied to it above the deadeye while the lanyard was rove and tied off. When the tackle was removed, the shroud and lanyard stretched taut. A similar procedure followed with stays.

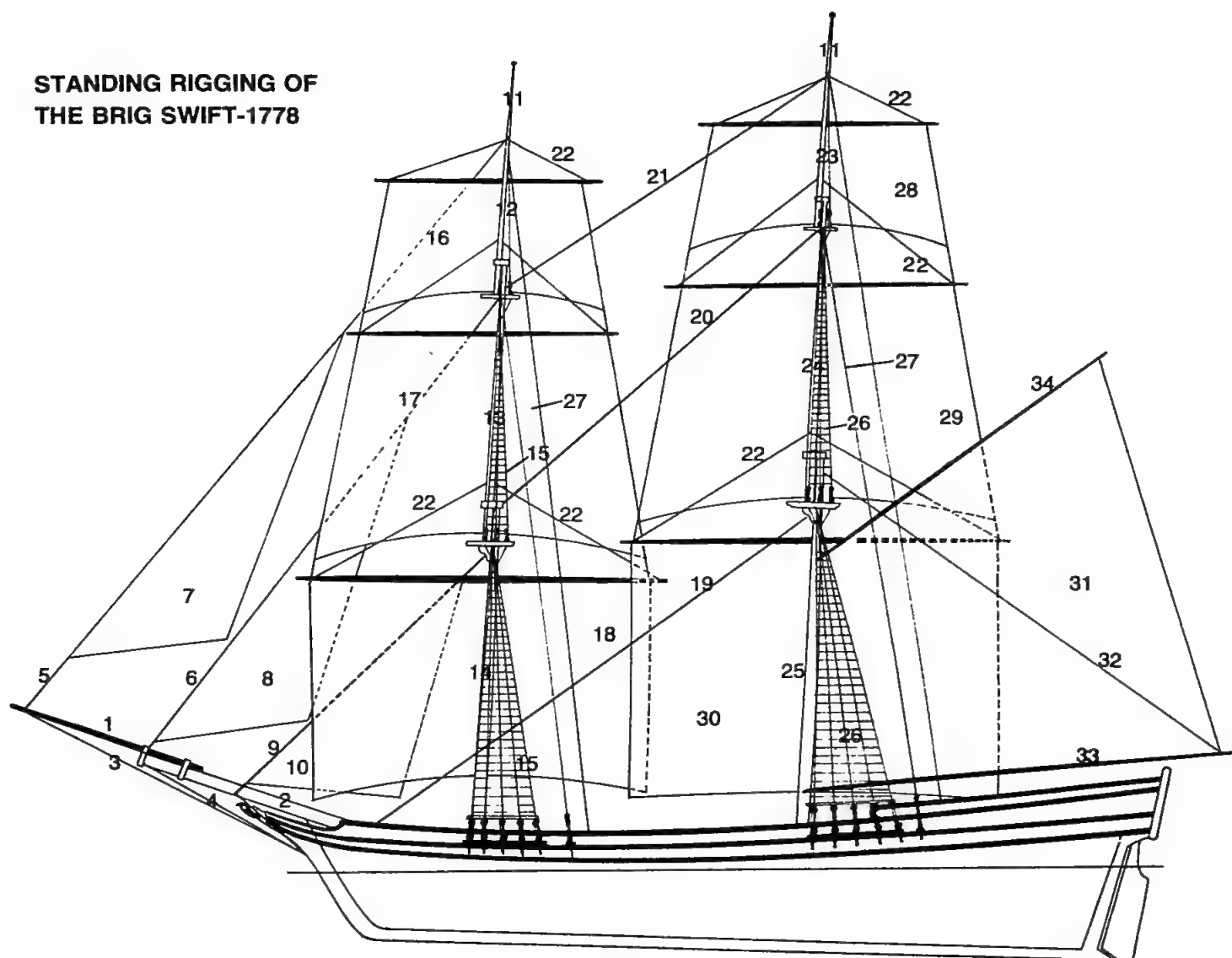
In the 17th Century the techniques described above held for most of the shrouds and the lower stays. The upper stays, however, were set up with

built-in tackle. For example, the main topmast stay led to a block on the head of the foremast, then down to a fiddle block which formed the running block of a four part tackle hooked into the deck.

The 17th century mizzen topmast stay illustrates another practice of the period that deviates from later principles. The stay divided in the middle and led to the main mast shrouds. To spread the load over a length of the shrouds elaborate systems of crow's feet stretched on either side from a point near the middle of the stay.

The practice of tying off one stay on another in this fashion was applied to spritsail topmast shrouds, the main topgallant stays and other places.

STANDING RIGGING OF THE BRIG SWIFT-1778



- 1 Jibboom
- 2 Bowsprit
- 3 Martingale
- 4 Bobstay
- 5 Fore Topgallant Stay
- 6 Fore Topmast Stay
- 7 Outer Jib
- 8 Inner Jib
- 9 Forestay
- 10 Fore Staysail
- 11 Flagstaff

- 12 Fore Topgallant Mast
- 13 Fore Topmast
- 14 Foremast
- 15 Fore Shrouds (named for their masts)
- 16 Fore Topgallant Sail
- 17 Fore Topsail
- 18 Foresail
- 19 Main Stay
- 20 Main Topmast Stay
- 21 Main Topgallant Stay
- 22 Lift (named for their sails)

- 23 Main Topgallant Mast
- 24 Main Topmast
- 25 Mainmast
- 26 Main Shrouds (named for their masts)
- 27 Backstays (named for their masts)
- 28 Main Topgallant Sail
- 29 Main Topsail
- 30 Main Course
- 31 Main Gaff Sail
- 32 Topping Lift
- 33 Main Boom
- 34 Main Gaff

Another feature of 17th and 18th century standing rigging was the use of crow's feet leading fan-like from a high point on the stays up to the forward edge of the tops. The crow's feet here protected the lower edges of topsails from chafing against the tops.

In general, 17th century rigging was more complex than that of later eras. In some cases, one might say, it was a rigger's nightmare.

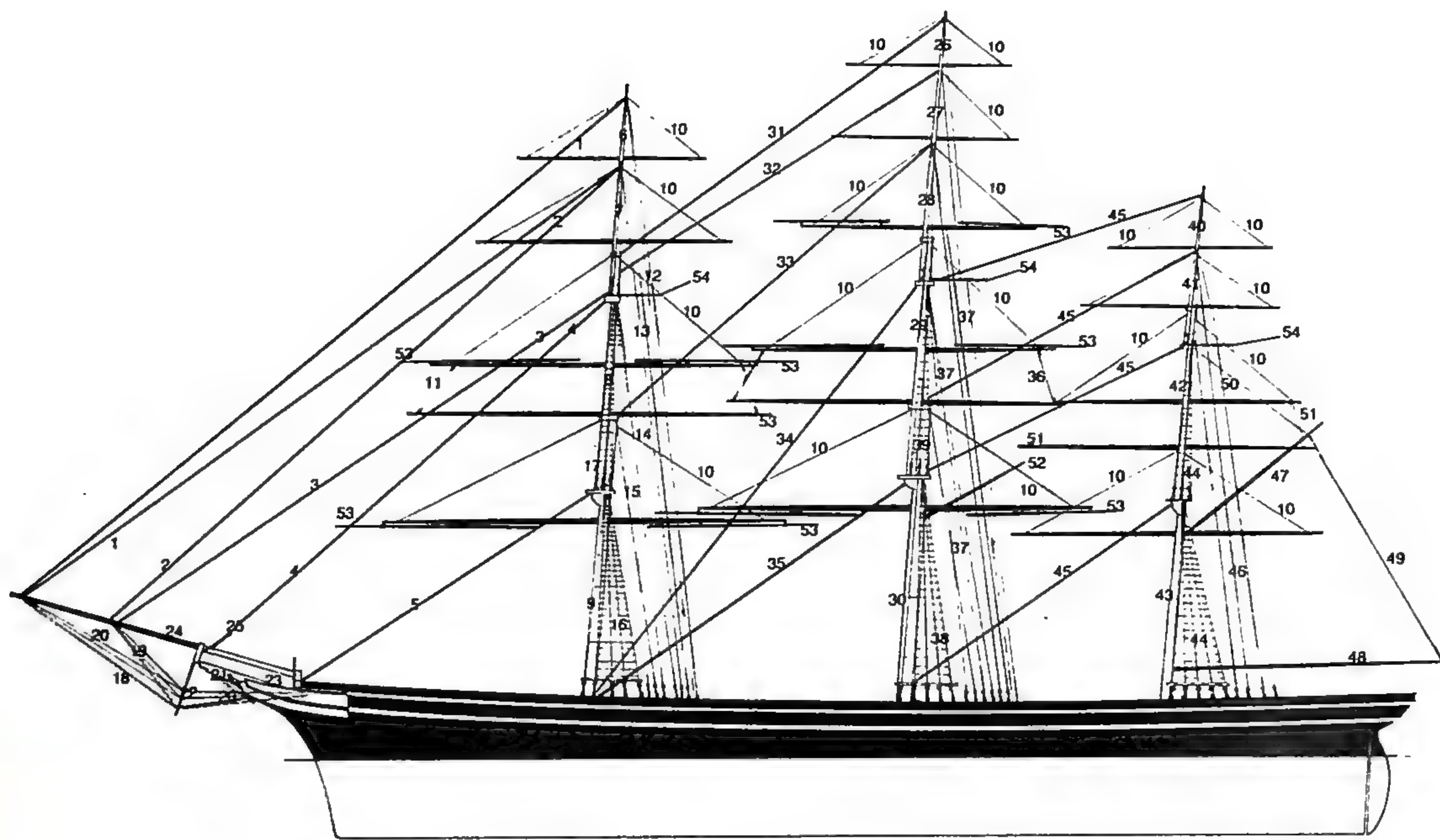
In principle, 18th and 19th century rigging was no different than that of the 17th. There were, however, differences in detail as well as an overall simplification. More deadeyes and hearts were applied to the upper mast rigging, crow's feet

became less elaborate and the number of shrouds per mast decreased. The most notable change came with the bowsprits which we have noted before.

When a ship was being fitted out, the mast tackles were the first rigging to go over the mast-head and worked to keep the mast aligned while the rest of the shrouds were set up. Thus, they were a kind of preliminary shroud.

Mast tackles were four to six part tackles variously rigged with whips or runners on their hauling ends with the standing blocks hooked to the channels. Once the shrouds were set up, the tackles could be loosened and used for general

STANDING RIGGING OF THE TEA CLIPPER "CUTTY SARK"-1869



- | | | |
|------------------------------|-----------------------------|---|
| 1 Fore Royal Stay | 19 Inner Martingale | 37 Main Backstays (named for their masts) |
| 2 Fore Topgallant Stay | 20 Backrope | 38 Main Lower Mast Shrouds |
| 3 Jib Stay | 21 Bobstay | 39 Main Topmast Shrouds |
| 4 Fore Topmast Stay | 22 Dolphin Striker | 40 Mizzen Royal Mast |
| 5 Fore Stay | 23 Bowsprit | 41 Mizzen Topgallant Mast |
| 6 Fore Royal Mast | 24 Jibboom | 42 Mizzen Topmast |
| 7 Fore Topgallant Mast | 25 Bowsprit Cap | 43 Mizzen Mast |
| 8 Fore Topmast | 26 Skysail Mast | 44 Mizzen Shrouds (named for their masts) |
| 9 Foremast | 27 Main Royal Mast | 45 Mizzen Stays (named for their masts) |
| 10 Lift | 28 Main Topgallant Mast | 46 Mizzen Backstays (named for their masts) |
| 11 Fore Upper Topsail Sheet | 29 Main Topmast | 47 Spanker Gaff |
| 12 Fore Royal Backstays | 30 Main Mast | 48 Spanker Boom |
| 13 Fore Topgallant Backstays | 31 Skysail Stay | 49 Topping Lift |
| 14 Fore Topmast Backstays | 32 Main Royal Stay | 50 Spanker Gaff Topping Lift |
| 15 Fore Backstay | 33 Main Topgallant Stay | 51 Mizzen Upper Topsail Sheet |
| 16 Fore Shrouds | 34 Main Topmast Stay | 52 Spencer Gaff |
| 17 Fore Topmast Shrouds | 35 Main Stay | 53 Stunsail Booms |
| 18 Outer Martingale | 36 Main Upper Topsail Sheet | 54 Swifters (backstay spreaders) |

heavy lifting, cargo handling and the like, and so performed a second duty.

In the 17th century, the main and foremast often had a pair of tackles on each side and additional tackles on the mainstay. The latter were the garnet and winding (pronounced wynding) tackles.

Yard tackles were rigged for cargo, boat and general lifting. Models often have no more than the short pendants hanging on the yardarms

which would be correct if the ship is assumed to be laid up. At sea, however, the pendants alone or the whole tackle would be lashed up against the yard to keep it from slatting around and tearing up the sail. If two or more ships were sailing together, the yard tackles were kept rove up because they were used for boat handling, and captains, under those circumstances, liked to visit each other.

NUMBERS OF SHROUDS

The number of shrouds per mast of a given size diminished through the centuries. The numbers given below are representative of the trend and are applicable to a mid-size ship. Larger or smaller ships might have one or two more or less than are shown. In general, upper masts carried about one half as many shrouds as the mast just below it.

The number of mizzen shrouds remained fairly constant because the load on the mizzen increased at the same time that fewer shrouds were being used elsewhere.

MASTS	17th	18th	19th
Foremast	9	7	6
Main Mast	10	8	7
Mizzen Mast	5	5	5
Fore Topmast	4	4	3
Main Topmast	5	4	4
Mizzen Topmast	3	3	3

RUNNING RIGGING

Running rigging is defined as all the lines intended to be hauled upon during a ship's routine operation. They may be subdivided into five functional groups.

1. Lines that lift and support spars and sails.
2. Lines that maneuver spars and sails while the ship is underway.
3. Lines that furl sails.
4. Lines used for cargo, boat handling and general lifting.
5. Supplementary and special purpose lines.

Earlier pages of this book deal with the most important of the lines controlling the spars and sails. It remains to deal with some of the less universal details.

Every ship was unique. All of them to be sure had the same basic operating lines—tyes, jeers, clews, buntlines and the like—but there similarity stopped. Each ship required special bits of rigging to insure that the basics would continue to function in various situations, and each captain applied his ingenuity to satisfy his ship's peculiarities.

Thus a modeller has an opportunity to add unique personal details to his ship which otherwise might remain an undifferentiated prototype.

Many modellers prefer to leave their models without sails on the grounds that sails obscure many rigging details or that it is difficult to get model sails to look right in scale. However, in giving up sails one also gives up the many interesting lines connected to them as well as many opportunities for the personal touches.

Let us consider some of the lines that can add to a model's feeling of authenticity.

On deck a variety of odd lines played roles that had nothing to do with the sails. *Lifelines* ran fore and aft along decks in heavy weather. A *ridge rope* was rigged taut between a pair of masts to support a tarpaulin or net over the deck. *Nippers* held the anchor cable to eyebolts in the deck. *Tiller ropes* rove from the tiller head to the drum of the

steering wheel. *Swifters* connected the outer ends of the capstan bars to keep the bars from flying off in case of accident. The *spurling lines* ran from the rudder head up to the wheel and operated a telltale which informed the helmsman of the position of the rudder.

Aloft in square riggers one might find a *pasaree* rigged to the ends of the stunsail booms and down to the lower clews of the foresail. A *slab line* might be rigged to the foot of a course so that its lower edged could be lifted up enough for the helmsman to see. *Spilling lines* might also drop down and around the sail to help spill the wind out of it before furling.

The lateen mizzen of an older ship might be fitted with a *smiting line* under the gaskets such that a single haul on it would loosen all the gaskets and set the sail quickly. Thus, the old expression "smite the mizzen."

The topsail parrel might have a *knave line* rigged to its after side to relieve its tendency to bind on the way up the mast.

Forward one might find a *timenoggy* rove from a point on the foretack up to the fore yardarm holding the tack line up and clear of the anchor stock. A *timenoggy* might be found on the main or fore sheets as well, keeping the latter clear of gun ports or, on the windward side, of the channels.

Fore and aft riggers had their own complement of supplementary lines. A *fancy line* held the lee topping lift against the mast so that the latter would not chafe the sail or spoil its aerodynamic shape. Booms might be fitted with *kicking straps* to prevent gybing in light airs.

Gill guys and *fair leads* were common devices for keeping lines from twisting and tangling with one another in their passage down to the pin rails and fife rails.

These lines and others are among the many details that could be found in a given vessel's rig.

A modeller can derive some extra satisfaction through research into such details and adding some sailor's imagination to his rigging job.

MODELLING HINTS

CORDAGE

Linen thread is the most popular and best recommended material for ship model rigging. Linen provides a clean hard rope-like finish and does not shrink or expand too much with changes in the weather. Cotton is less satisfactory though some modellers use it to good effect. Artificial fibers such as Nylon or Dacron, however, should be avoided because they are too elastic.

Linen rigging line is available in hobby stores and through ship model mail order distributors in a variety of scale dimensions and with black or natural finishes.

Black is for tarred standing rigging; natural for the running rigging.

The "natural" colored linen is often too white to simulate hemp correctly so modellers often dye it slightly with strong coffee or tea.

The thread looks better if it is "de-fuzzed" with a treatment of beeswax or a dilute clear acrylic wood finish such as Deft.

Linen rigging is available in sizes ranging from .25 to 1.75 millimeters in natural color and from .25 to 1 millimeter in black.

Surgical silk or a strand unravelled from a heavier line can work for thin lines, servings and the like.

SOFTENING THREAD

Linen and other thread in small diameters exhibits a certain springiness, which can be a nuisance during such operations as tying ratlines. This problem can be relieved by soaking the thread in fabric softener.

SCALE CONVERSION

Ship modellers often work out scale conversion charts as a guide in selecting the right sized line for their particular model. Ship model kits and plans come in large number of different scales.

Many experienced modellers use a micrometer to measure line thickness and some go to the extreme in selecting or fabricating rigging line to precise scale dimensions. Most modellers, however, do not fuss over a few hundredths of a millimeter and simply use the standard model rigging line closest to the requirement.

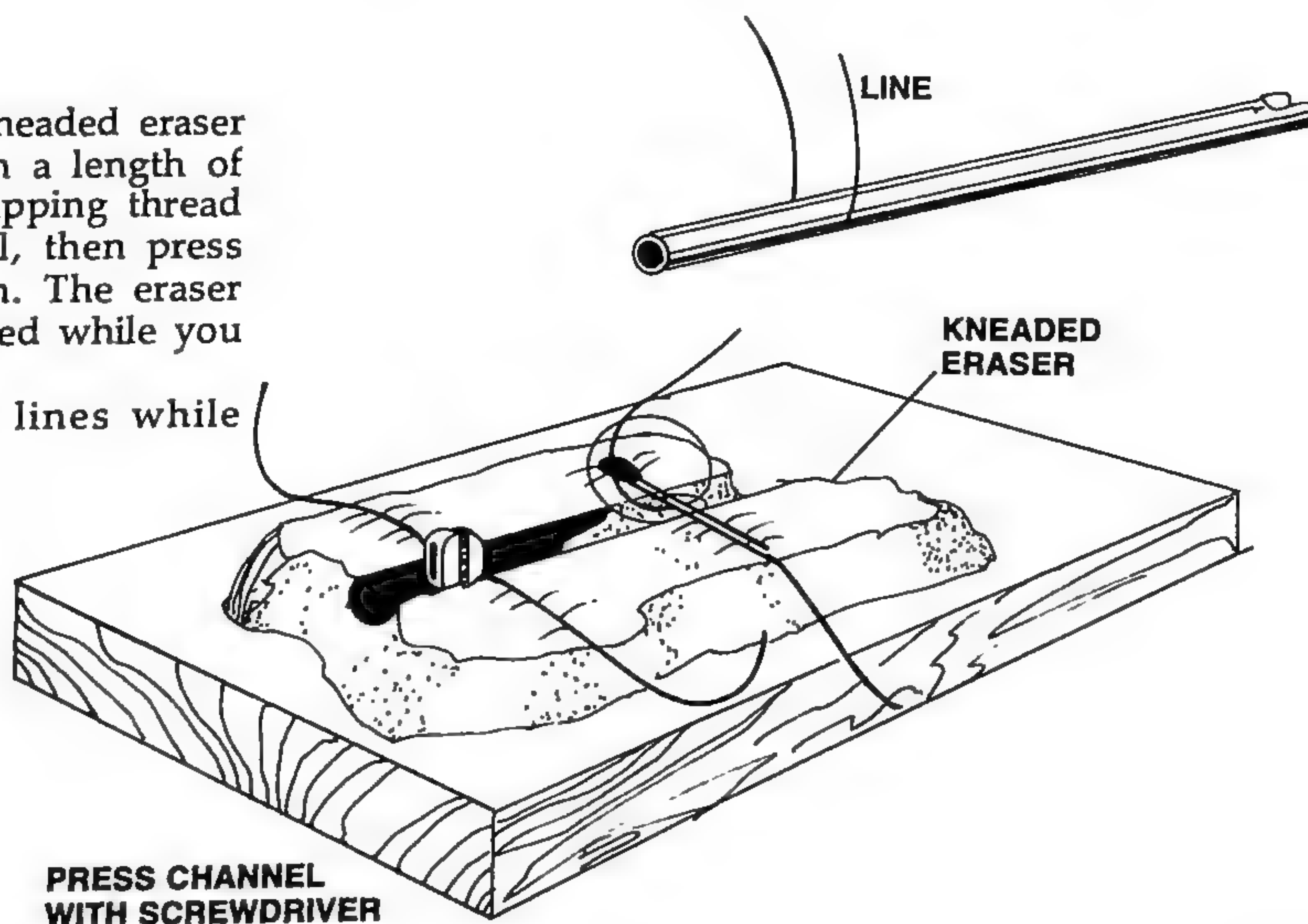
The chart below will serve for the scales of $\frac{1}{8}" = 1'-0"$; $\frac{3}{16}" = 1'-0"$; and $\frac{1}{4}" = 1'-0"$.

Size of Rope in the real Ship	Size of Model Rope Dia. in Millimeters (1 Millimeter = .0393 inches)		
	$\frac{1}{8}" - 1'-0"$	$\frac{3}{16}" - 1'-0"$	$\frac{1}{4}" - 1'-0"$
Diameter in Inches	$\frac{1}{96}$	$\frac{1}{64}$	$\frac{1}{48}$
$\frac{1}{4}"$	.07	.10	.13
$\frac{1}{2}"$	.14	.20	.27
$\frac{3}{4}"$	.21	.30	.40
1"	.28	.40	.53
1 $\frac{1}{2}"$	.42	.60	.80
2"	.56	.80	1.07
2 $\frac{1}{2}"$	.70	1.00	1.34
3"	.84	1.20	1.61
3 $\frac{1}{2}"$	.98	1.40	1.88
4"	1.12	1.60	2.15

STRAPPING AND REEVING

Press a channel into a piece of kneaded eraser (available in art supply stores) with a length of tube or screw driver. Press the strapping thread into the eraser athwart the channel, then press the block over it exactly in position. The eraser will hold the block and thread aligned while you tie the strap.

Use the same trick to support lines while clapping on seizings.

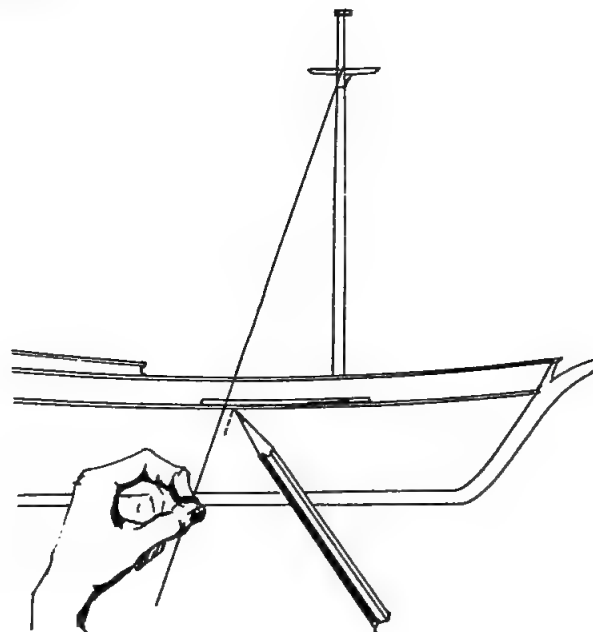
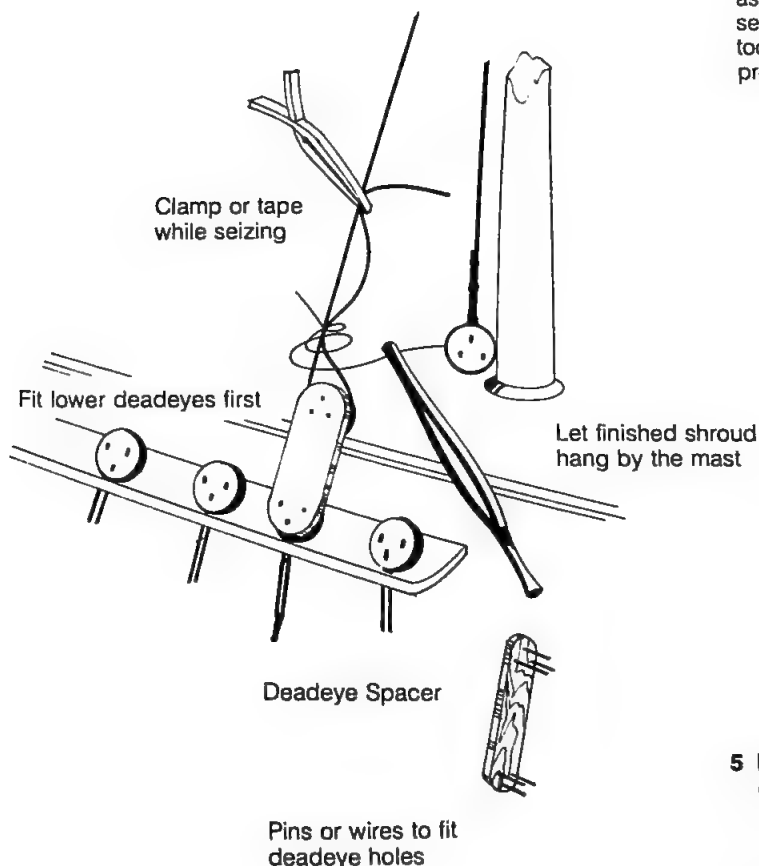


SETTING UP SHROUDS/REEVING DEADEYE LANYARDS

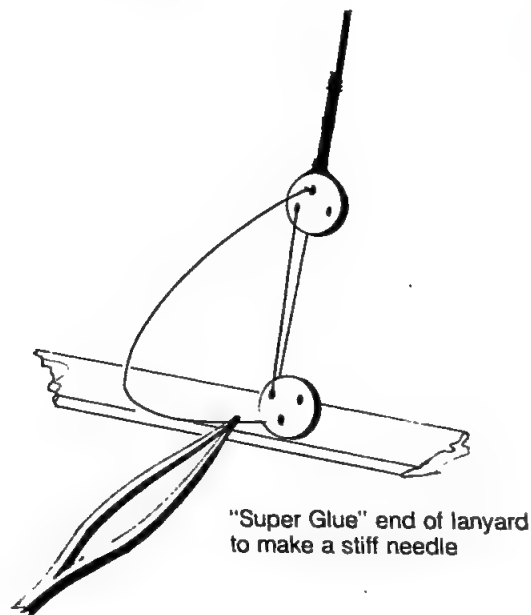
1 Set up the lower mast and plot the line of the shrouds past the channel to the hull side to determine the correct alignment of the chain plates.

2 Install the lower deadeyes and chain plates.

3 The shrouds will go around the masthead in pairs. The first pair begins at the foremost lower deadeye on the starboard side and goes up around the masthead and back down to the second deadeye on the starboard side. The bight is round seized where the two ends go around the masthead. The second pair repeats the process to port, while subsequent pairs alternate from starboard to port. If there is a remaining odd shroud, it will run from starboard to port and be fitted around the masthead with a "cut splice." Place the seizings on the pairs of shrouds before fitting them to the masthead, put them over and slide the seizings up. Make the cut splice by seizing a short length of material to the odd pair.



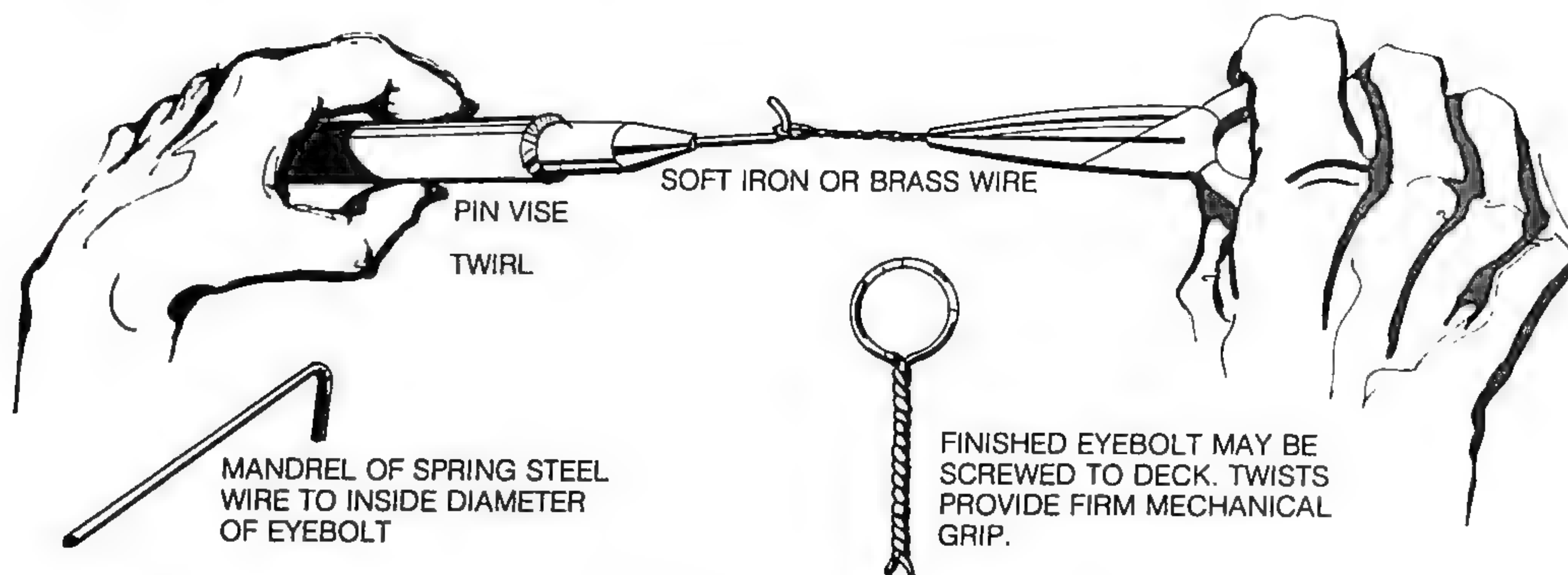
4 Make a deadeye spacer as shown in the illustration and turn in the upper deadeyes starting with the foremost on the starboard side, followed by the one to port. Keep the tension even from side to side being sure that the mast stays straight as you work aft. As each set of deadeyes is turned in and seized, secure the seizings with glue, then remove the spacer tool and let the turned in shrouds hang by the mast while you proceed to the next pair.



5 Reeve the lanyards starting again with the foremost on either side. Make a "needle" out of the end of your lanyard material by soaking a half inch of it in "super glue."

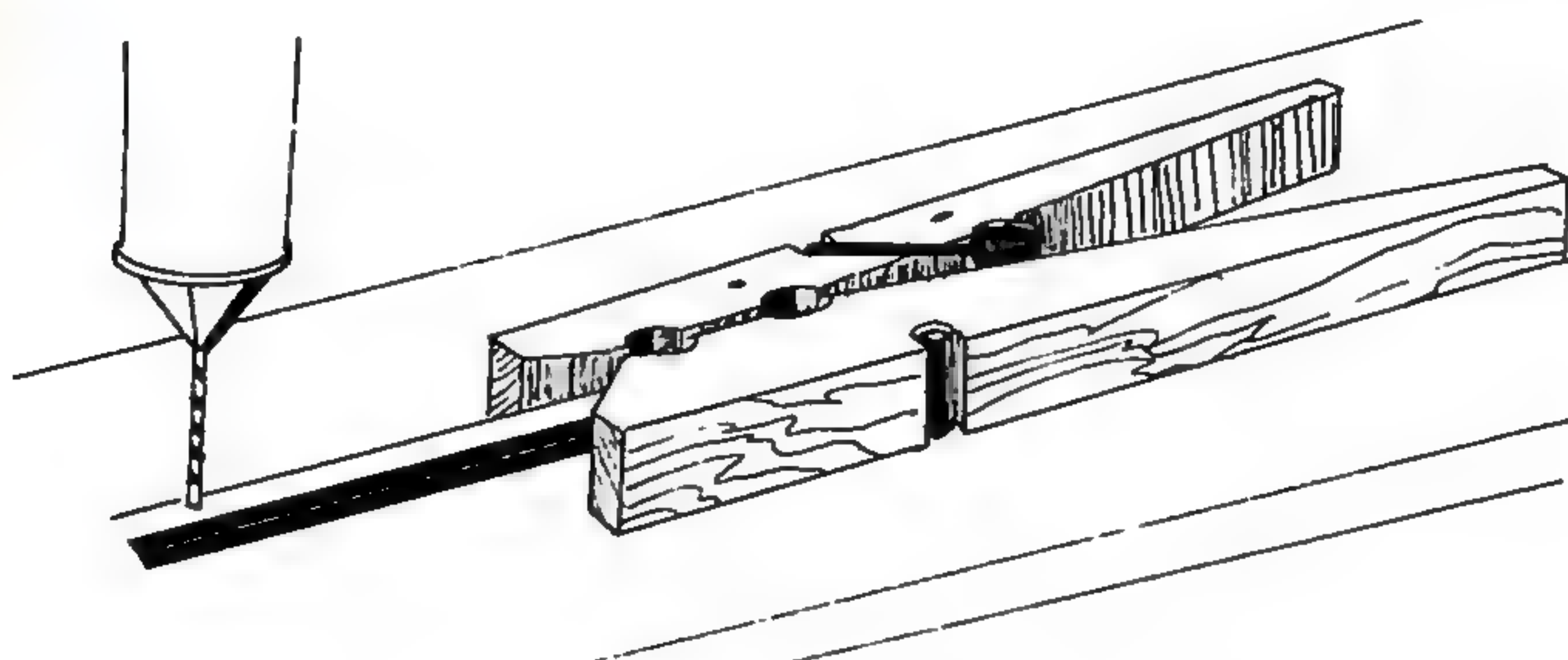
Remember in setting up standing rigging that the first lines to go around the masthead are the mast tackles, then the shrouds from forward-starboard to forward-port and so on aft; and finally the stays.

EYE BOLTS AND OTHER FASTENINGS



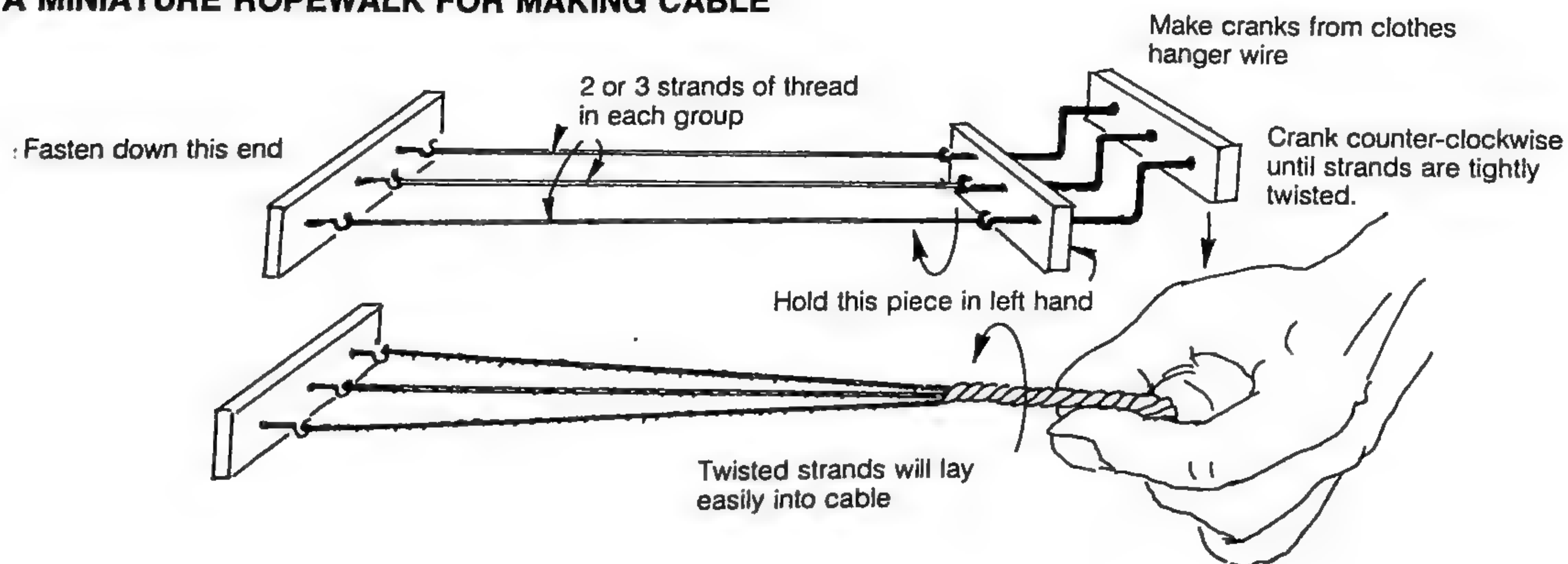
Ship models require large numbers of eyebolts which while small in size, must be strong. Beginners frequently underestimate the tension that can be developed in the rigging of a model. Fife rails, pin rails, tops, channels, bobstays and so forth are remarkably prone to breaking if they are not built for maximum strength. Wherever possible, these fastenings should be provided solid mechanical joints with the hull such as bolts, dowels, screws, or mortice and tennon joints. Glue alone should remain suspect.

Commercially available eyebolts usually are bent so that one end of the ring simply butts up against the pin end leaving a real possibility that the bolt will unfold under tension. This is particularly true of soft iron or brass wire eyebolts. A better alternative is to twist a length of wire using a mandrel, pin vise and pair of pliers as shown. Mandrels of the correct diameter may be bent of spring steel wire. Larger diameter spring steel may have to be heated to be formed. If so, heat, form then heat again and immediately douse the mandrel in cold water.



Form a drilling jig by fastening down one side of a spring clothes pin groove out the work board to clear the spring

A MINIATURE ROPEWALK FOR MAKING CABLE

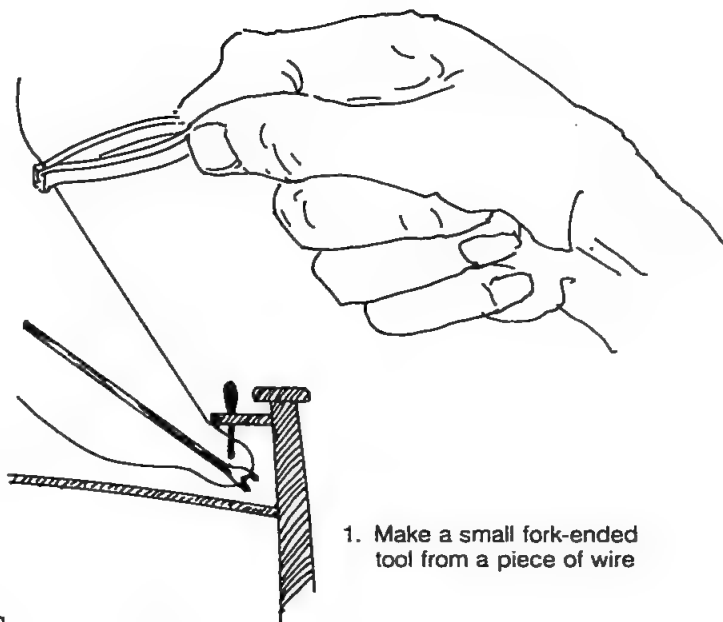


BELAYING AND TYING OFF

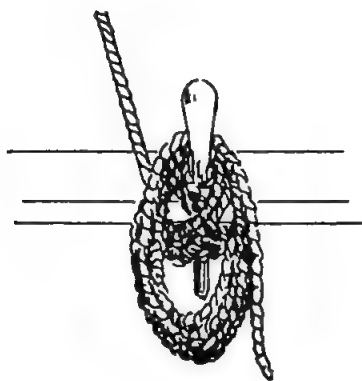
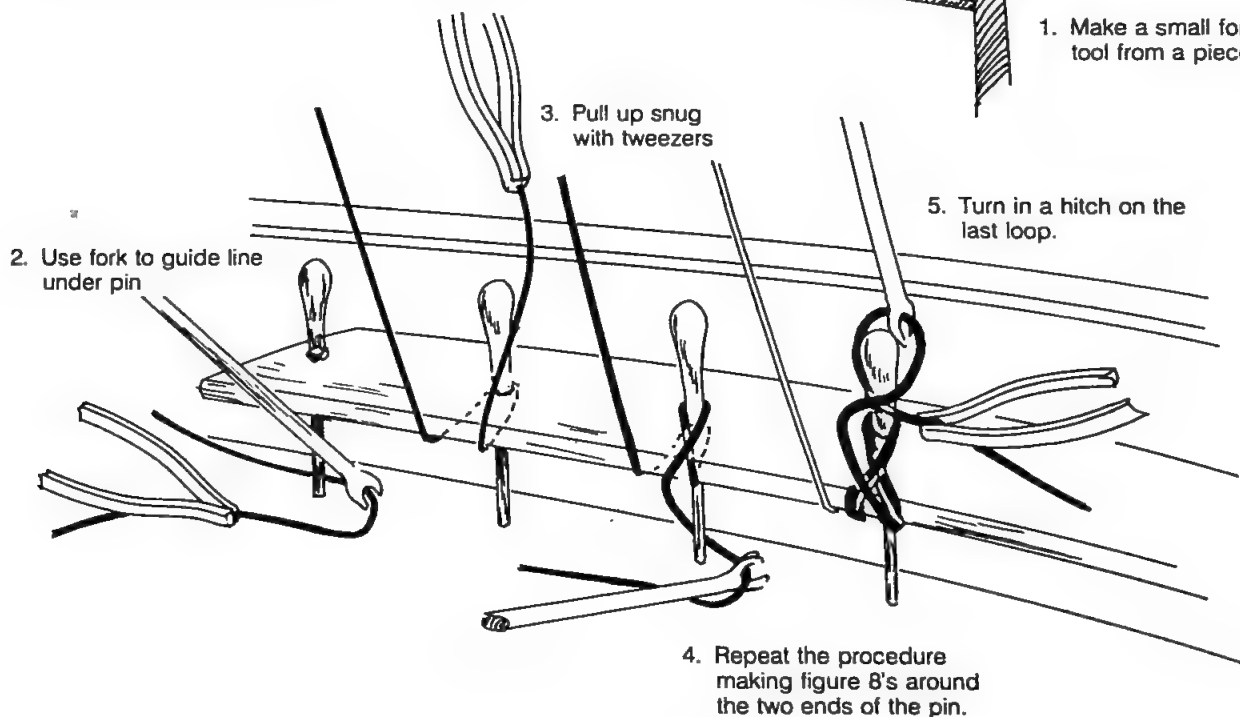
Each line of a ship had its own belaying point, the place where it was made fast on deck, at the top or other place. Each ship had its own belaying pattern depending on its type, era, and the style of its captain. Many model plans include a chart of the ship's belaying points and should be used as the authority for the vessel in question.

A few general principles may be observed, however. First, the lines of the higher sails were tied off aft of those of lower sails, creating a fan pattern emanating from the mast tops more or less like the shrouds. Thus the principle "the higher the line, the further aft on the pin rail it is belayed."

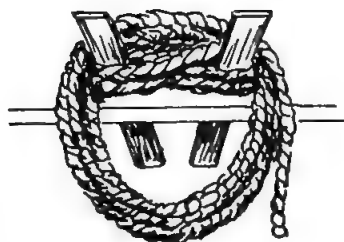
From fore to aft the clews, bunts and leeches usually followed in sequence for each yard.



1. Make a small fork-ended tool from a piece of wire



Coils look like this on the rail



Coil on a kevel



Larger lines may be made into flat coils

This rope is made up for storage



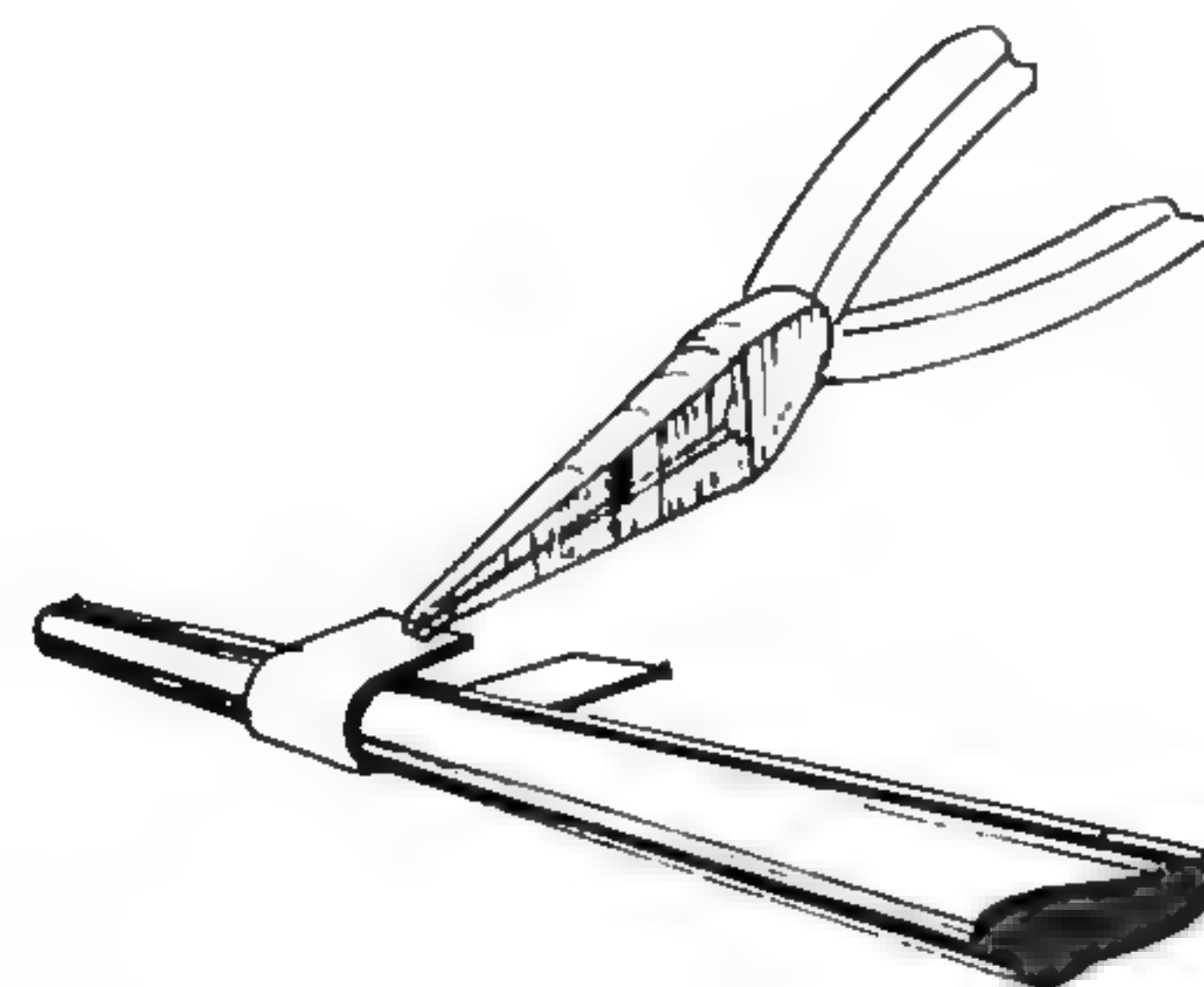
METAL WORK

Though many of the small metal parts necessary to a ship model may be obtained as prefabricated fittings, some modellers like to make them from scratch. There are hundreds of techniques that may be employed in such work which a craftsman may wish to investigate. A good place to start looking would be a handbook on jewelry making.

The suggestions below cover a few of the basics:

BASIC METAL WORKING TOOLS:

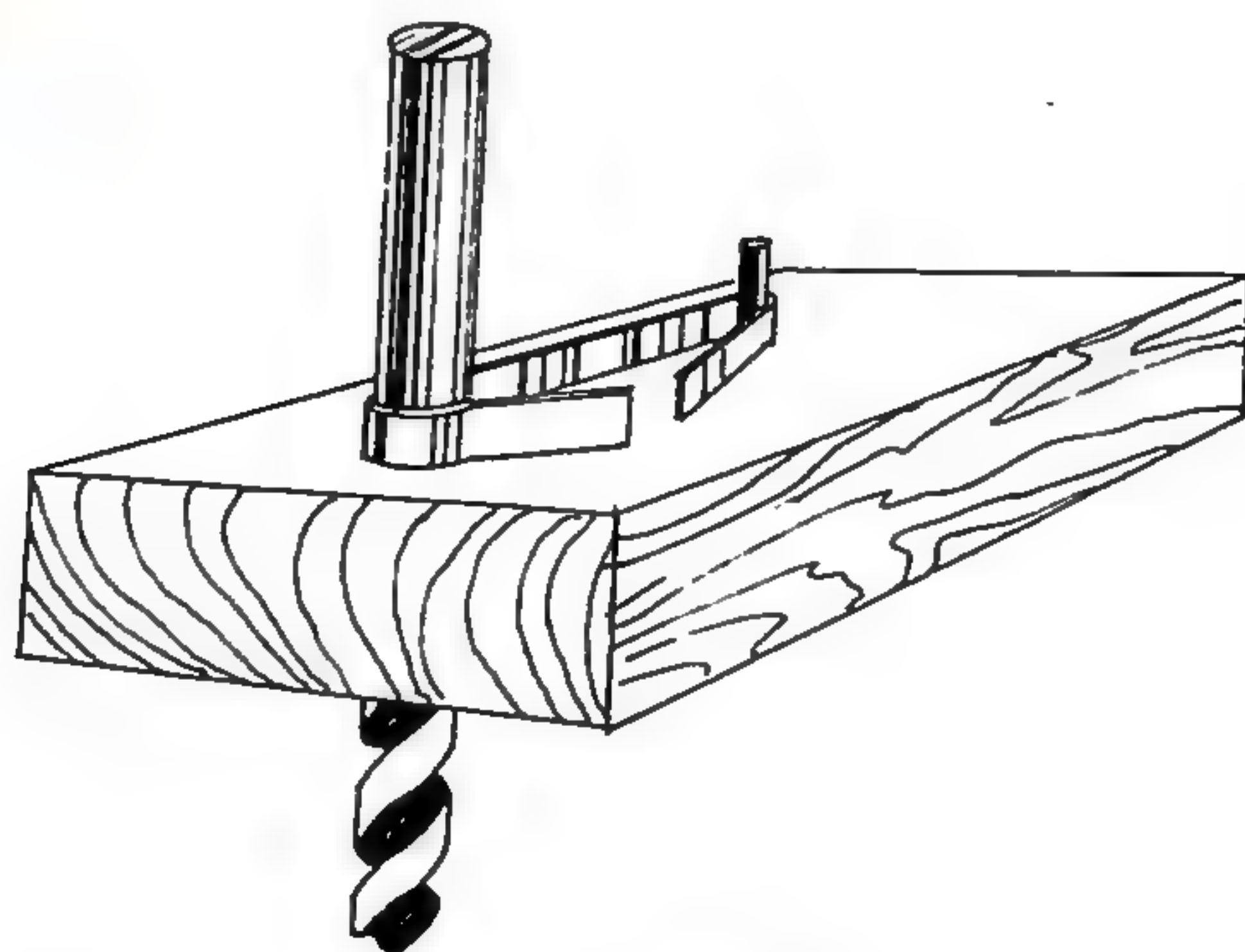
VISE(S)
 HAND VISE(S)
 PIN VISE(S)
 MANDRELS
 ANVIL(S)
 MILL FILES - small in various cross sections
 PLIERS - small, needle nose, round, semi-round and square
 TWEEZERS - standard, self locking
 DRILLS - #75 up
 SNIPS OR SCISSORS
 JEWELLER'S SAW
 TUBE CUTTER
 BALL AND PEEN HAMMER(S) - small
 TORCH - Jeweller's breath operated alcohol type for hard solder,
 or;
 PINPOINT SOLDERING IRON - for soft solder
 EMERY CLOTH OR PAPER
 SMALL BUFFING WHEEL
 TRIPOLI - or automobile rubbing compound



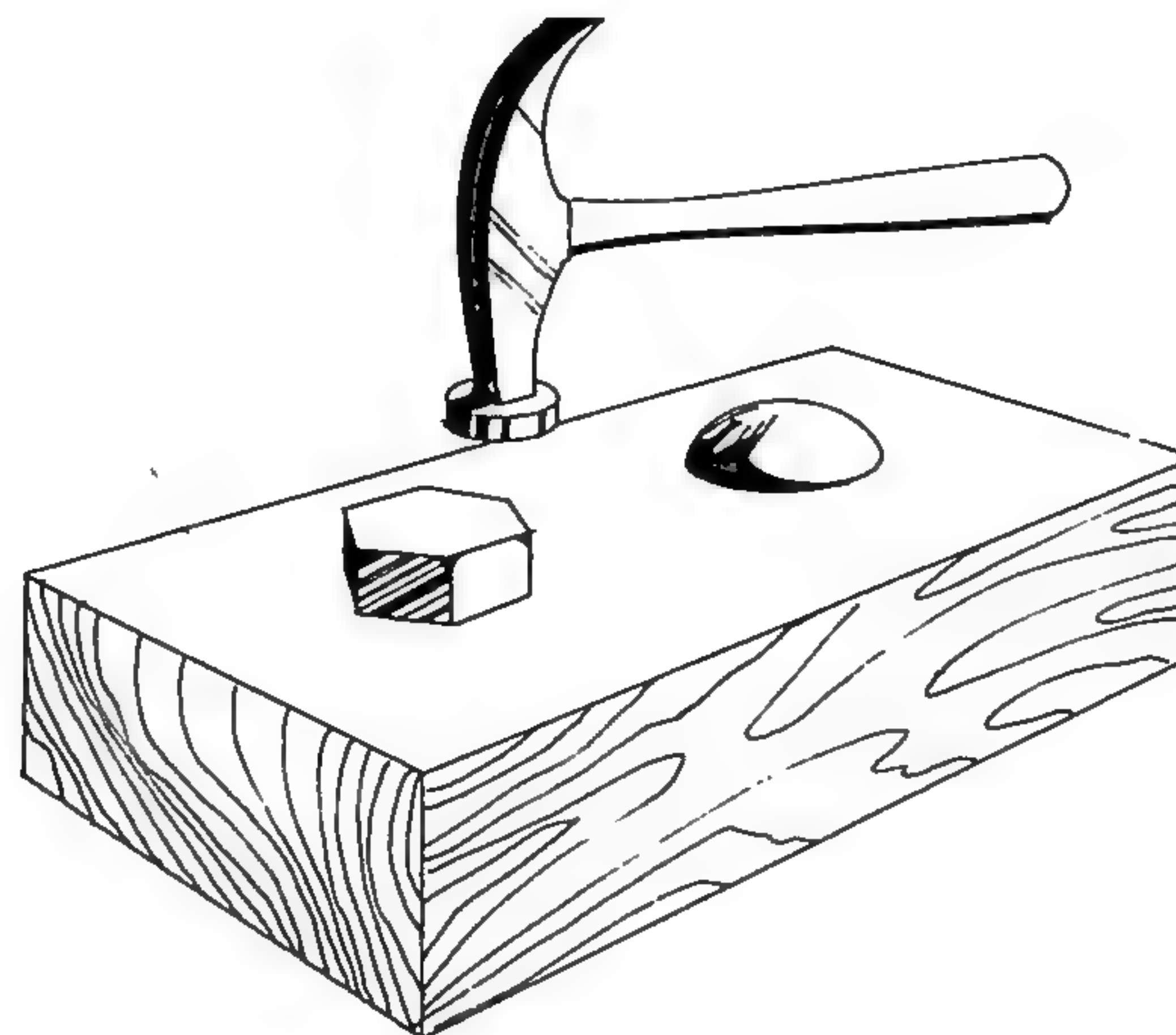
Sheet metal is most easily formed over mandrels. A jeweller's ring mandrel tapering to various diameters is a useful tool made for the purpose, but bolts, nuts or other hardware of the right size will work just as well.



Mill files are available in a variety of cross sections.



A link such as that in a chain plate may be formed to the correct diameter(s) by using the shank of a properly-sized twist drill sunk into a piece of wood.



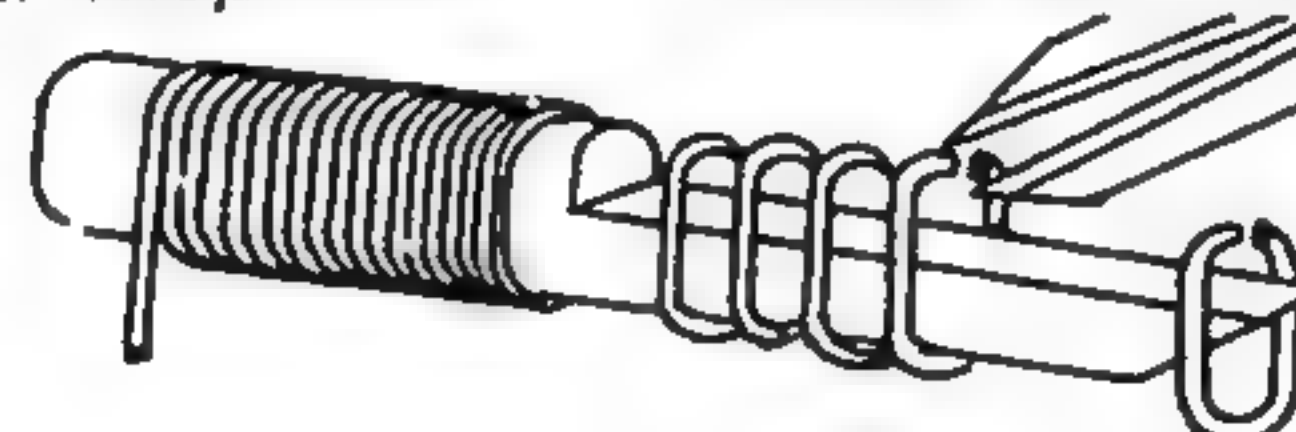
Anvils may be made by sinking heavy carriage bolts into a block of hardwood.

MAKING CHAIN

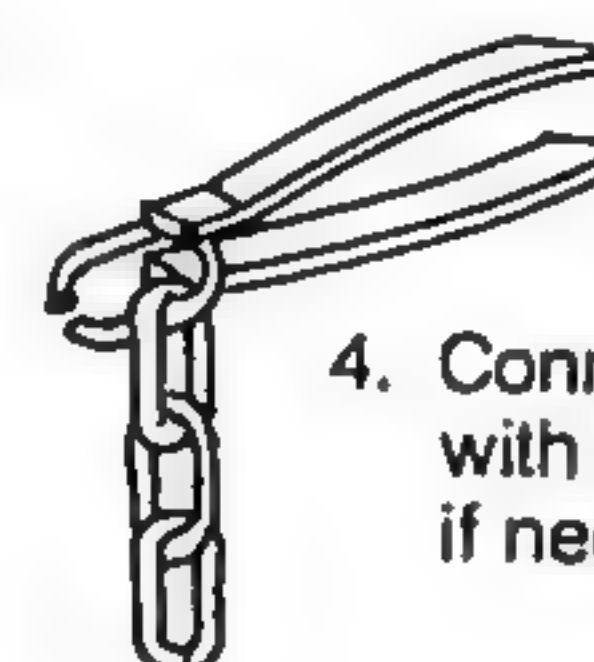
1. Shape a dowel like this



2. Wrap wire



3. Move links down and snip



4. Connect and close links with tweezers—solder if necessary

SOLDERING

Solder joins two pieces of metal together by becoming alloyed with them. Heat causes both the solder and adjoining metals to partly melt together into a kind of molecular bond.

There are two varieties of the technique; hard and soft, though both require that the metals to be joined have a higher melting point than the solder or filler itself.

Hard soldering (sometimes called brazing) employs a filler with a melting point above 800 degrees. The most common of these is silver solder which is an alloy of silver, copper and zinc.

Silver itself has a melting point of about 1761 degrees; copper 1981 degrees; and zinc 787 degrees. The proportions of these metals in a particular solder determine its melting point.

Soft soldering employs lead and tin alloy fillers which have melting points as low as 360 degrees.

Both hard and soft solder find their place in ship modelling. Each has its advantages. Hard solder is by far the stronger of the two and can be hammered and shaped with the same freedom as the

original metal. But fittings must be made from iron or copper. Brass of the sort popular with modellers has too low a melting point to be workable at hard soldering temperatures.

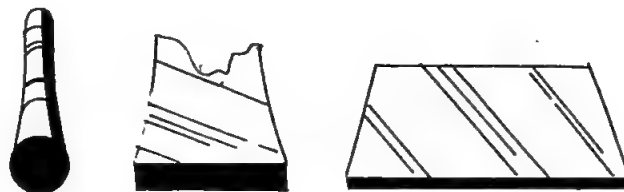
Soft solder, because it requires less heat, may be employed with brass. It also requires no more than a conventional soldering iron while hard soldering requires a torch.

Soldering requires a flux which serves as vehicle for carrying the molten alloy into and through the joint. The solder will flow where the paste or liquid flux lies. 20 Mule Team Borax in a water paste works with silver solder. Lead/tin solders might have a rosin or acid core as a built-in flux.

A wide variety of solders are available in hobby shops and hardware stores ranging from hard to soft. They differ in the proportion of metals in their alloys and in the type of flux.

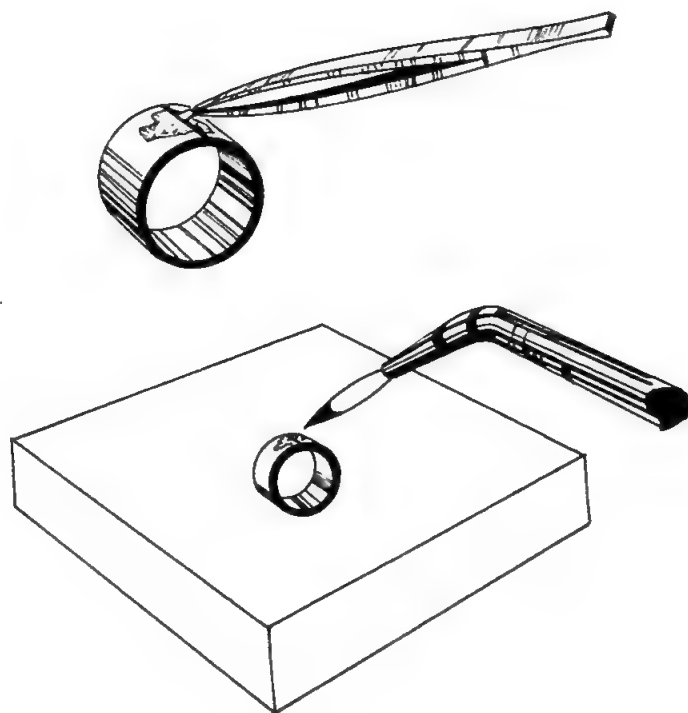
There are also soft soldering pastes on the market. With the paste one can stick two pieces of metal together as he would glue wood, then heat them to obtain a fine soldered joint.

SILVER SOLDER COMES IN WIRE, RIBBON OR SHEET



SILVER SOLDERING PROCEDURE

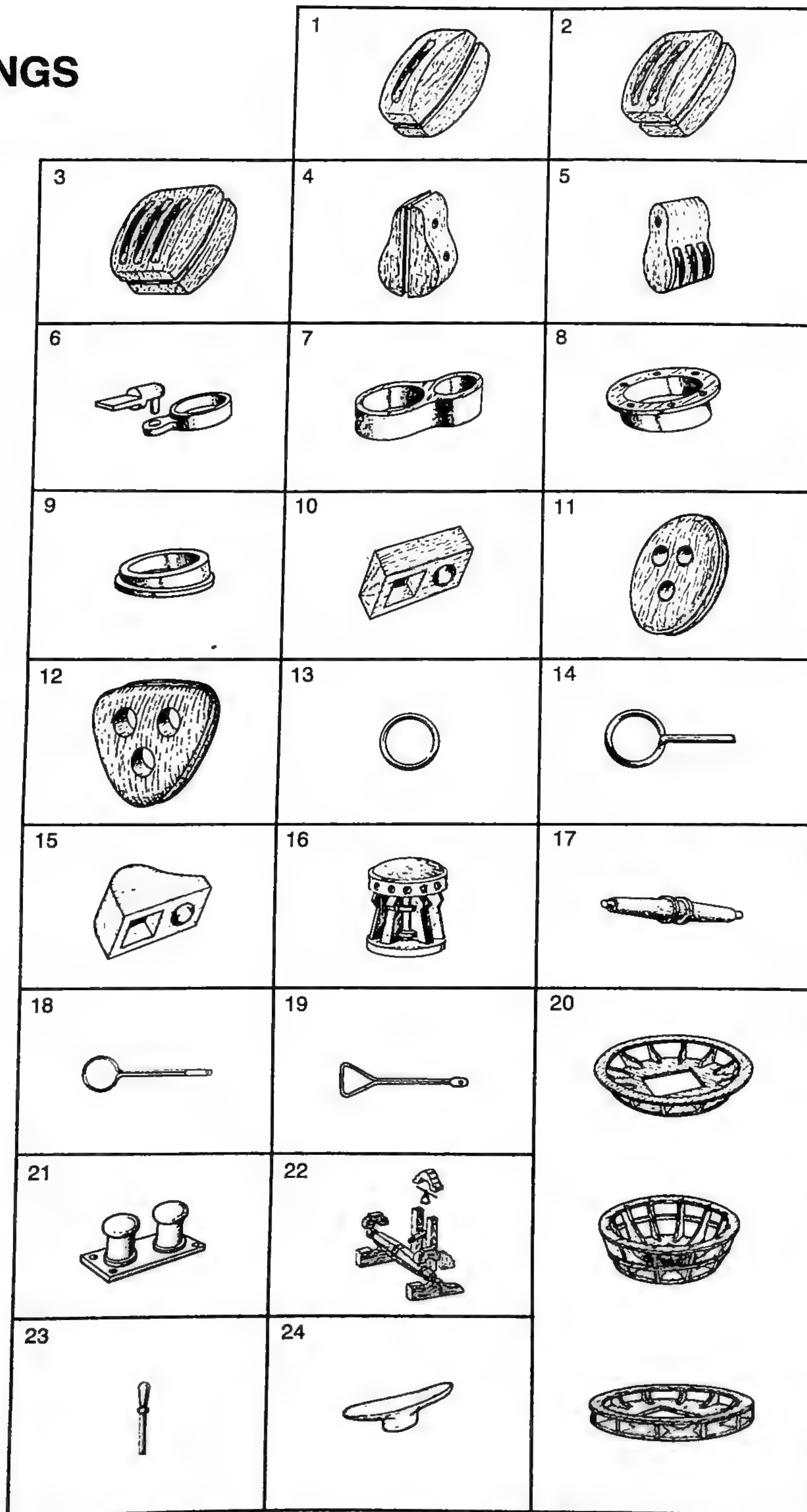
- 1 PLACE PART TO BE SOLDERED ON A HEARTH OF FIRE BRICK OR CHARCOAL
- 2 APPLY FLUX (20 MULE TEAM BORAX PASTE) TO JOINT WITH TOOTHPICK
- 3 PLACE SMALL FLAKE OF SILVER SOLDER OVER JOINT WITH TWEEZERS
- 4 HEAT JOINT WITH BLUE TIP OF TORCH FLAME UNTIL SOLDER FLOWS. REMOVE HEAT IMMEDIATELY.
- 5 COOL PART IN WATER AND FINISH JOINT WITH FILE.



COMMERCIALLY AVAILABLE FITTINGS

Ship model kit manufacturers as a rule offer lines of prefabricated fittings in various sizes. This list is a representative sampling of rigging fittings currently available in many U.S. hobby shops.

- Sail Winch
- One Ball Stanchion
- Two Ball Stanchion
- Burnished Chain
- Brass Chain
- Ball Chain Parral
- Brass Bell
- Brass Stanchion
- 23 Belaying Pin - Walnut
- 23 Belaying Pin - Box Wood
- 23 Belaying Pin - Brass
- 13 Brass Ring
- 13 Burnished Ring
- 14 Brass Eye Screw
- Burnished Eyelet
- Single Brass Bit
- Black Rigging Rope
- Clear Rigging Rope
- Wooden Pump
- Box Wood Helm Set
- 7 Brass Mast Cap
- 8, 9 Brass Mast Foot
- 10, 15 Wood Mast Cap
- Brass Chain Plate
- Brass Thimble
- Eyebolt w/Ring
- 24 Cleats
- Brass Turn Buckle
- Deadeye Burnished Strop
- Chain Plate Assembly w/Deadeye
- 1 Single Walnut Block
- 1 Single Box Wood Block
- 2 Double Walnut Block
- 2 Double Box Wood Block
- 3 3 Eye Walnut Block
- 3 3 Eye Box Wood Block
- 4 Box Wood Sheet Block
- 3 Eye Box Wood Sister Block
- 5 3 Eye Walnut Sister Block
- 11 Walnut Dead Eye
- 11 Box Wood Dead Eye
- 12 Box Wood Heart Block
- 12 Walnut Heart Block
- Walnut Open Heart Block
- Box Wood Heart Blocks
- Net Mesh
- Wood & Brass Capstan
- Burnished Capstan
- 16 Box Wood Capstan
- Brass Winch
- 17 Walnut Windlass
- 22 Walnut Windlass Kit
- Burnished Brass Windlass
- Brass Nails
- Copper Nails
- 18, 19 Brass Chain Plate Assembly
- 6 Brass Gooseneck
- 20 Box Wood Top
- 21 Brass Bollards



SHIP MODEL KITS

Most ship model hobbyists prefer to build from a kit. There are of course the dedicated scratch enthusiasts who happily commit themselves to the thousands of hours of work necessary to such an effort. But a fine kit is certainly a satisfying experience.

However, in approaching a kit the modeller is advised to be aware of several facts. First, ship model kit manufacturers are faced with the problem of scale. There is the need on one hand for a model to come out to a convenient finished size while real ship prototypes range in size from 20 to 2000 feet. Thus a single scale for a manufacturer's line of ship kits is next to impossible. At the same time, it is prohibitively expensive to produce fittings to match the wide range of scales. Clearly a compromise is necessary if the manufacturer is to offer a product at an affordable price.

In fact many manufacturers have solved this problem quite effectively, but the modeller should be aware that even the finest of kits may contain some unavoidable anomalies, or simplifications in the interest of standardization.

SOURCES OF PLANS AND INFORMATION

Whether building a kit or from scratch, ship modellers often find themselves engaged in historical research or in need of authoritative plans.

Plans may be obtained through several sources. First, kit manufacturers frequently make their kit plans available as separate items which may be obtained through hobby dealers. Then there are a number of specialized plans service in the U.S. who sell by mail order. The Smithsonian Institute in Washington, D.C. and the National Maritime Museum in Greenwich, England have giant collections of plans which may be obtained by specific request.

FOR PLANS CONTACT:

Taubman Plans Service
11 College Drive, Box 4G
Jersey City, NJ 07305

Smithsonian Institute
Curator of Transportation
Washington, D.C. 20560

National Maritime Museum
Greenwich S.E. 10
England, U.K.

FOR RARE BOOKS CONTACT:

Buccaneer Books
P.O. Box 518
Laguna Beach, CA 92651

FOR ADVICE, INFORMATION AND FUN CONTACT:

Ship Modeler's Association
1044 North Richman Avenue
Fullerton, CA 92635

Among the more common of these are:

- 1) A single weight of line for all running rigging
- 2) A single weight of line for all standard rigging
- 3) A single size for all single, double or triple sheaved blocks
- 4) Out of period fittings

Second, kit rigging plans are often simplified. Minor lines and occasionally some major lines are left out, while others that in life would have been tackles, are specified as straight hauls. Sometimes plans call for patently impractical leads such as a sheet led squarely in front of a gun. Here again the modeller should be prepared to apply his independent judgment and imagination.

Third, some kits, in addition to plans, attempt to provide a sequence for construction. These sequence instructions are frequently undependable. If strictly followed, the modeller might easily arrive at a totally impossible situation where, for example, he is expected to fit a dozen eye bolts into the deck under a fife rail with twenty lines already tied off on it.

The advice here is to work out one's own sequence plan whether one is in the kit or not. Plan an order of installation for every fitting such that as each part is fitted it will not interfere with the installation of subsequent ones.

Maritime museums generally have vast storehouses of information as well as plans and are among the best sources available to ship modellers.

Local libraries are the most convenient place to begin a search for information though a great deal of maritime lore is locked in obscure and out-of-print books. For this reason many ship modellers make a habit of prowling in used and antique book shops. In this way, they create their own libraires of rare books which, incidentally, become extremely valuable.

Rare or out-of-print books may also be obtained through book search companies, the largest of which is Buccaneer Books listed below:

MARITIME MUSEUMS

<i>Name</i>	<i>Place</i>	<i>Country</i>			
Addison Gallery of Art	Andover, MA	U.S.A.	New York Historical Society	New York, NY	U.S.A.
Alands Sjöfartsmuseum	Mariehamn	Finland	Norsk Sjöfartsmuseum	Oslo	Norway
Altonaer Museum	Hamburg	W. Germany	Old State House, Bostonian Society	Boston, MA	U.S.A.
Atwater Kent Museum	Philadelphia, PA	U.S.A.	Orlogsmuseet	Copenhagen	Denmark
Boston Marine Museum	Boston, MA	U.S.A.	Peabody Museum of Salem	Salem, MA	U.S.A.
Boston Museum of Fine Arts	Boston, MA	U.S.A.	Penobscot Marine Museum	Searsport, ME	U.S.A.
Buffalo Historical Society	Buffalo	U.S.A.	Philadelphia Maritime Museum	Philadelphia, PA	U.S.A.
Cheasapeake Bay Maritime Museum	St. Michaels, MD	U.S.A.	Port Adelaide Nautical Museum	Port Adelaide	Australia
Civico Museo Navale	Genoa	Italy	Portsmouth Naval Shipyard Museum	Portsmouth, VA	U.S.A.
Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik	Munich	W. Germany	Queen Mary Museum	Long Beach, CA	U.S.A.
Francis Russel Hart Nautical Museum	Cambridge, MA	U.S.A.	River Museum (The)	Marietta, OH	U.S.A.
Franklin D. Roosevelt Memorial Library	Hyde Park, NY	U.S.A.	Sandefjord Sjöfartsmuseum	Sandefjord	Norway
Franklin Institute	Philadelphia, PA	U.S.A.	San Francisco Maritime Museum	San Francisco, CA	U.S.A.
Great Lakes Museum	Detroit, MI	U.S.A.	Sjöfartsmuseum i Goteborg	Goteborg	Sweden
Handels og Sjöfartsmuseum pa Kronborg	Helsingor	Denmark	Smithsonian Institution	Washington, D.C.	U.S.A.
Imperial War Museum	London	Great Britain	Sofartssamlingerne ved Svendborgsund	Troense, Taasinge	Denmark
Kennebec Valley Marine Museum	Bath, ME	U.S.A.	South Street Seaport	New York, NY	U.S.A.
Kon-Tiki Museum	Oslo	Norway	Star of India	San Diego, CA	U.S.A.
Marinemuseet	Horten	Norway	Statens Sjöhistoriska Museum	Stockholm	Sweden
Marine Museum of the City of New York	New York, NY	U.S.A.	Submarine Library and Museum	Groton, CN	U.S.A.
Mariners Museum	Newport News, VA	U.S.A.	U.S. Maritime Commission	Washington, D.C.	U.S.A.
Marinmuseum och Modelkammaren	Karlskrona	Sweden	U.S. Merchant Marine Academy	Kings Point, NY	U.S.A.
Maritime Museum of Canada	Halifax, N.S.	Canada	U.S. Naval Academy	Annapolis, MD	U.S.A.
Musee de la Chambre de Commerce	Marseilles	France	U.S. Navy Department	Washington, D.C.	U.S.A.
Musee de la Marine	Paris	France	Virkingskiphuset	Oslo	Norway
Museo Maritimo	Barcelona	Spain	Vojenno-Marskoi Moezjei	Leningrad	U.S.S.R.
Museo Naval	Buenos Aires	Argentina			
Museo Naval	Madrid	Spain			
Museo Storico Navale	Venice	Italy			
Museu de Marinha	Lisbon	Portugal			
Museum of Science and Industry	Chicago, IL	U.S.A.			
Muzeum Marynarki Wojenne	Gdynia	Poland			
Mystic Seaport	Mystic, CN	U.S.A.			
Nantucket Whaling Museum	Nantucket, MA	U.S.A.			
National Scheepvaartmuseum	Antwerp	Belgium			
National Maritime Museum	Greenwich	Great Britain			
Naval Historical Foundation	Washington, D.C.	U.S.A.			
Nederlandsch Historisch Scheepvaart Museum	Amsterdam	Netherlands			
Nelson Museum	English Harbor, Antigua	West Indies			
Newport Historical Society	Newport, R.I.	U.S.A.			

A number of periodicals contain plans or advertise their availability. Among these are:

The American-Neptune	Salem, MA	U.S.A.
The Mariner's Mirror	Greenwich	England
Model Shipwright	Greenwich	England
The National Fisherman	Camden, ME	U.S.A.
Nautical Research Journal	Washington, D.C.	U.S.A.
Wooden Boat	Brooklin, ME	U.S.A.

ACKNOWLEDGEMENTS

This book came into being because I have had the support and advice of a good number of knowledgeable and generous people. At the top of the list is my partner, D.J. Roberts, who suffered with me through the hundreds of painstaking tasks which necessarily accompanies a work of this kind.

Next in line are my many friends of the Ship Modelers Association of Fullerton, California whose work and wisdom never ceases to dazzle me. Everyone in the Association has contributed to this volume one way or another, though a few must be singled out for specific thanks.

Photos of Henry Bridenbecker's masterful model of the Brig Irene are most important illustrations for which we are grateful.

Art Robinson allowed us to select photos from his huge collection for use here, while providing us a storehouse of ingenious modelling hints.

Thanks also to Don Dressel for allowing us to use a photo of his pirate brig model.

We owe a debt of thanks to a number of experts in the "business" of ship modelling whose long experience in meeting the hobbyists' needs have provided invaluable advice.

Ideally all of these individuals and companies should be listed here but space precludes our doing so. So rather than mention a few to the exclusion of their competitors we have chosen in the interest of fairness to acknowledge their help with a simple "thanks to the industry."

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London, 1972
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New York, 1978
- Campbell, G.F.
Jackstay
Bogata, NJ, 1962
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New York, 1973
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London, 1802
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New York, 1975 (reprint)
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New York, 1970 (reprint)
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London, 1819
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Dana Point, CA, 1979
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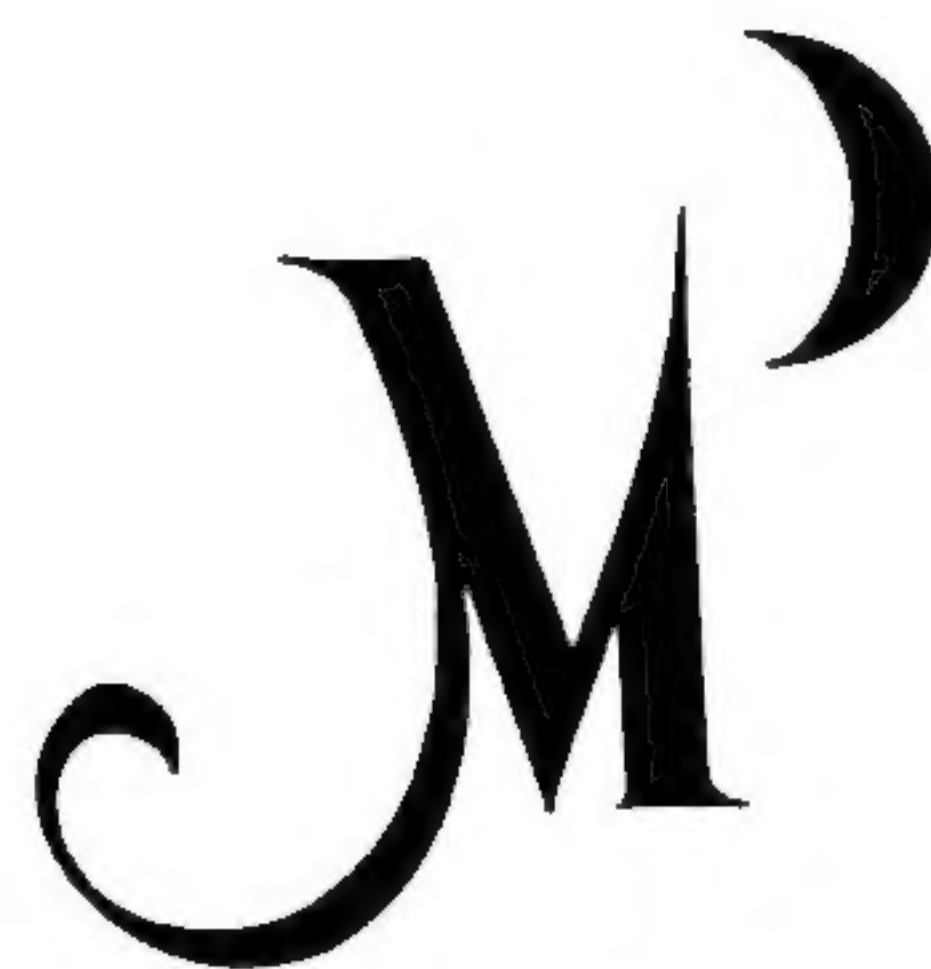
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Below are listed the brand names of the most well known ship kit manufacturers whose lines are available in the U.S. Most hobby shops with ship kit lines either stock models by these manufacturers or have their catalogs. Otherwise hobbyists may obtain kits, fittings and materials through several ship model mail order houses in the U.S. Two of the larger of these are:

Model Expo
23 Just Road
Fairfield, New Jersey 07006

James Bliss & Co., Inc.
100 Route 128
Dedham, Mass. 02026

Aeropicola
Billing
Blue Jacket
C. Mamoli
Carta Augusto
Corel
Dumas
ERTL
Fisher, A.J.
Fuji
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Laughing Whale
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A Beginner's Guide**

**A Modellers Guide to
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**ESSENTIAL INFORMATION FOR
MODELLERS OF CLASSIC
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**A COMPARISON OF RIGS
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